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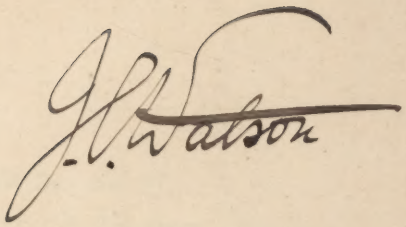

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Dyeing in Germany and America

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Dyeing in Germany and America

WITH A CHAPTER ON COLOUR PRODUCTION

A REPORT

To the Electors of the Gartside Scholarships on the results of a Tour in Germany and the United States in 1905-6.

BY

SYDNEY H. HIGGINS, M.Sc.,

Gartside Scholar.

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THE GARTSIDE REPORTS.

The Gartside Reports are the reports made by the Gartside Scholars at the University of Manchester. The Gartside Scholarships were established in 1902 for a limited period, by John Henry Gartside, Esq., of Manchester. They are tenable for two years and about three are awarded each year. They are open to males of British nationality who at the date of the election shall be over the age of eighteen years and under the age of twenty-three years.

Every scholar must enter the University of Manchester for one Session for a course of study approved by the electors. The remainder of the time covered by the scholarship must be devoted to the examination of subjects bearing upon Commerce or Industry in Germany or Switzerland, or in the United States of America, or partly in one of the above-mentioned countries and partly in others, but the electors may on special grounds allow part of this period of the tenure of the Scholarship to be spent in study and travel in some other country or countries. It is intended that each scholar shall select some industry, or part of an industry, or some business, for examination and investigate this comparatively in the United Kingdom and abroad. The first year's work at the University of Manchester is designed to prepare the student for this investigation, and it partly takes the form of directed study, from publications and by direct investigation, of English conditions with regard to the industrial or commercial subjects upon which research will be made abroad in the second year of the scholarship. Finally each scholar must present a report upon the matters that he has had under examination. The reports will as a rule be published.

The value of a scholarship is about £80 a year for the time spent in England, £150 a year for time spent on the Continent of Europe, and about £250 a year for time spent in America.

PREFACE.

In presenting this report the writer is conscious of the magnitude of the task undertaken, and asks the reader's indulgence on that score.

The arrangement and form has been left to the writer, but suggestions from various sources have been adopted. He originally intended to avail himself of statistics of imports and exports of the three countries under consideration, but the fact that the figures are so unsatisfactory in general; that they can be so differently interpreted; and that England, which caters principally for home consumption, has no adequate record of home trade, has led him to abandon the idea. Figures for aniline compounds are certainly of importance, but they are not issued separately, and therefore no satisfactory conclusions can be arrived at. Nor can a country's prosperity be gauged by merely considering its imports and exports. The home consumption is of importance, inasmuch as the English Aniline Colour Industry would be considered highly prosperous if we supplied our own needs, and there were no imports and exports. Likewise America might be highly prosperous and yet have little or no foreign trade. In reading figures it must always be remembered that the main quantity of business is local, and that exchanges take place more between the members of a community themselves than between the community and the outside world.

It must be obvious that generalisations as to the state of this industry in a country is a matter of some difficulty, not only because of the extremes of perfection and imperfection that will always exist, but also because of the unusually progressive nature of the industry since the application of chemical science.

With regard to the visiting of works, it has been stated

that whereas the English manufacturers were willing to grant every facility, the Germans, on the contrary, were most reluctant. This has not been the writer's experience. He met with rebuffs in both countries—quite as many in England as in Germany—but, at the same time, many German manufacturers went to the greatest trouble on his behalf, and treated him with the utmost courtesy. Of course, he found some people reticent, but, on the whole, he was agreeably surprised at their candour and readiness to help. In all their actions he found the Germans shrewd and alert, yet at the same time courteous and obliging. Introductions to the various manufacturers were obtained through the Chambers of Commerce in Germany, the professors of chemistry, the large colour concerns, and from the various Consuls. To all of these the writer desires to express his thanks. He is especially indebted to the Secretary of the Manchester Chamber of Commerce, who so kindly placed him in contact with gentlemen holding similar positions to his own in German and Swiss towns, and to Mr. J. Hübner for his introductions to colour and machine works in Germany.

In America he was fortunate in seeing most of those mills he particularly wished to visit. He was introduced by the agents of the German colour works and by the lecturers at the American colleges, while in some cases a mere statement of his object proved a sufficient means of introduction. As in Germany, he was well received, and during his visit to America he could hardly complain of being told too little. All the places mentioned in the text were visited, and at one German works the writer for three months was actually engaged in the industry. The Exhibition at Liége was visited, but the observations were hardly worthy of record here since the authorities seemed to have considered the pleasing of tourists more than the information of the mere student of industry. As regards both Germany and America, detailed mention has only

been made of works where something of exceptional interest was to be recorded, and in some cases names, for obvious reasons, have been withheld.

The writer thought of introducing some general views on industrial life in the countries visited, and also of including some impressions of general interest; but, seeing that much has already been written upon these things by persons of the greatest experience, a large collection of notes has been omitted. Detailed matter on colour production in Germany has also, for want of space, been omitted. It was thought to include some notes and comparisons of the educational methods and institutions of the countries visited, but it was felt that an entirely different class of readers would thus be catered for. Although the writer has come to conclusions which are entirely antagonistic to the prevailing ideas and to the different reports on these matters, yet he refrains from publishing his views until a more suitable opportunity presents itself.

In conclusion, he desires to thank Mr. Arthur Jones, M.A., for the unusual trouble he has taken with the work in manuscript, and Prof. S. J. Chapman and Mr. F. Foster, M.Sc., for valuable corrections and advice.

S. H. H.

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CHAPTER I.

GENERAL.

Distribution of the industry in Germany and America—The development of the art of dyeing—Influence of chemistry—Opposition to progress—Hank dyeing and washing—Cloth Dyeing.

As to the location of the industry and districts covered by this report, we have in Germany—(1) *North-west Germany*, including Rhineland and Westphalia; (2) *Middle Germany*, containing what is usually called "the Saxony industry," but spread over a big area; the industry here is very old—400 years; (3) *South-west Germany*, which is connected with the French and Swiss industries, and is likewise scattered; Mülhausen is the principal town.

In the first district we have Crefeld, the seat of the silk industry; Gladbach, of the cotton; and Elberfeld-Barmen, for general manufacture, especially dyeing. Other neighbouring places, as Aachen, have important dyeing establishments. Chemnitz and Zwickau are the important centres of district 2. Chemnitz is called "die Sächsiche Manchester," and its inhabitants are proud of the name. Rheinelanders, however, prefer to call Manchester "die englische Gladbach" than M. Gladbach "die rheinische Manchester." Both German places only resemble our city in that they are engaged in similar manufacture. The South-west boasts Mülhausen, a very important fine cotton centre, which resembles the other two towns as far as unpleasant appearance is concerned. The manufacturing towns in Germany stand in vivid contrast to those in which manufacture is not so vigorous. Mülhausen is

crossed by canals, and is situated upon a river which is often very low. It has few fine buildings and no broad streets.

The works at Mülhausen dye and finish in an exquisite manner the finest of counts coming from England and France, and being afterwards returned. The work is totally different from that seen in other parts of Germany. The Gladbach industry is on the coarse side, the making of such things as cotton blankets being important. Chemnitz has a wide range, but does not treat such fine counts as Mülhausen.

The machines used in the industry are in many cases English, and even in the trade schools I came across many machines from Manchester and district. The textile school at M. Gladbach has nearly all Manchester machinery. At the same time, the German engineering industry is thriving, and even pushing its really good machines into our textile industry.

In America the dyeing industry is very scattered, and the various States have works of different kinds. Many of these are only on a small scale, and show a lack of specialisation. Indeed, only in the extent of its production is the dyeing industry of the United States remarkable. In Philadelphia the dyeing is principally of carpets and coarse goods. It is job dyeing, and thus meriting little notice, my attention was turned to other quarters. The Southern industry is more recent than the Northern; nevertheless, although there are some fine new bleachworks there, yet the New England States, being more developed, were selected for my tour. In addition I visited New Jersey and New York States.

Nearly everything that is made anywhere in the United States is made in New York State. It has a population of over seven millions, a foreign commerce only exceeded by four countries, and is the leading State of the United States in many important industries. Yet, turning farther

North, we find New England contains two-thirds of all the cotton spindles and three-quarters of all the looms of the United States, while Fall River makes three-quarters of the print cloth of America. It is evident that this particular quarter was the most interesting to me, and in this neighbourhood most of my time was spent.

The art of dyeing is very old. Pliny says: "Garments are painted in Egypt in a wonderful manner, the white cloths being first smeared, not with colours, but with drugs which absorb colours. These applications do not appear on the cloths, but when the cloths are immersed in a cauldron of hot dyeing liquor they are taken out painted the moment afterwards. It is wonderful that, although the dyeing liquor is only of one colour, the garment is dyed by it of several colours, according to the different properties of the drugs which have been applied to the different parts; nor can this dye be washed out. Thus the vat, which would doubtless have confused all the colours if the cloth had been immersed in a painted state, produces a diversity of colours out of one, and at the same time fixes them immovably." Here we have the practice of what Hummel termed "polygenetic colour dyeing." It shows great knowledge of the art, and it is surprising that only in the last few centuries have big strides been made. The last century has really brought marvellous advances. The discovery of America influenced the dyer's art so materially that its proper development dates from that event. For Mexico furnished cochineal, and, later, the beautiful tropical indigo displaced the ancient woad of England. An Act of Parliament in 1552 limited the number of colours that might be used. William III. added to the list, and later legislation allowed free trade in dyestuffs.

Chemistry has indefinitely enlarged the resources of the art by showing how to produce varieties and shades of colour extending through the whole range of the prismatic

spectrum, and has enabled the dyer to fix and render durable many of those beautiful vegetable dyes the ephemeral nature of whose brightness formerly detracted from their utility. Along with these improvements the nature of the substance to be dyed has received careful scientific consideration. Thus chemistry has adapted the processes to the substances operated upon, and mordants of many kinds have been introduced by which peculiar shades may be produced, the most diverse fabrics may be dyed together, and perfect fixity given to the colours.

Yet during all this time the industry has had to combat many prejudices, the greatest of which has been the reluctance of the dyers thmselves to adopt the new methods introduced. They could not conceive of the utility of colours dyed without mordants. It was a long time before the substantive cotton colours could get a footing, and there are other examples of this kind. Thus the use of metallic mordants has always been opposed. It was the discovery of alizarine red and later of alizarine blue which brought in this method, and, in spite of opposition, it has gradually grown in use, until now it is one of the most prevalent methods of dyeing. The one bath method for dyeing wool is still regarded suspiciously in some quarters. Dyers deem preliminary mordanting essential to produce fastness, and do this, time after time, apparently heedless of the progress their art has made. It must be remembered that every improvement in every trade is received by opposition of some kind, and, in the history of dyeing, this circumstance continually recurs. The preliminary difficulties may be great, and unwillingness to discard the old methods may exist, but the very fact that the new methods gain acceptance in other quarters show their final utility, and ought to urge all beyond personal obstacles. In the two bath method for dyeing wool longer boiling is needed, and this so weakens the fabric that the finest counts will not

endure much of this treatment. In one bath methods we have less boiling, and, in spite of belief to the contrary, the after chromed colours are quite as fast as the mordanted ones, and in some cases faster. Also the quickness of the method and consequently the saving of labour has to be considered.

We have been told that the success of many chemical industries depends on such economic considerations as cost of labour and waste of material, and that the success of a venture is often determined more by these than by the actual process. Having this in mind, single bath methods only need to be once tried to be adopted by every up-to-date dyer in the industry.

Dyeing in Europe was first effected in the yarn form, and this method is still largely used.

Hank dyeing has not changed much during the last century, and in all industrial districts men can be seen standing over the wooden vats changing periodically the wooden sticks from which the hanks hang into the dye liquor. Lift, turn and drop back again. To still further improve the evenness of the dyeing it is necessary that the positions of the hanks be changed regularly so that all experience the same concentration of dye.

Machines have been devised to imitate this movement, but these have not received universal acceptance. They are only suitable when large quantities of material are to be dyed one colour. I did not come across any such machines in Germany—it may be that I was unfortunate—but in America the Klauder-Weldon machine was often seen. (See page 56.) In the United States, however, hank dyeing is on the decline, so that the importance of these machines must be on the wane. In America they make so many cloths where the warp is the same count as the weft that both warp and weft are receiving the same treatment before weaving. Both are dyed together on the warp dyeing machine, and then taken, part to be quilled

and part to be beamed. This is said to be a cheaper process, and there is a tendency to adopt this method in all quarters. Referring to the machines mentioned, it is evident that these can never wholly replace hank dyeing by hand, which they attempt to imitate. Certain colours require a special kind of turning, and it is useless to attempt to devise machines to meet each special case.

After dyeing, the hanks must be washed. This operation is of great importance. The simplest method is by passing the hank round and round between a pair of squeezing rollers, and at the same time through water. In Germany very often the rollers were replaced by square pieces of wood covered with porcelain. These are driven while the hanks are on them. Just as in the dyeing, washing machines have been introduced which imitate the movement used during washing by hand. In one machine the hank is lifted rapidly out of the water, plunged rapidly in again, and at the same time turned.

Haubold's—a large machine firm in Chemnitz, Saxony —build a machine which is very economical and has a big capacity. It consists of a circular tub into which fresh water is conducted at one side of a partition whilst the dirty water flows out at the other side of that partition. In this way we have the hanks first meeting dirty water and getting cleaner and cleaner until, when almost clean, they meet the cleanest water, and are taken out. (This is the principle of counter currents described on page 25.) From the centre of the trough there are iron rods fixed together radially in the form of a wheel, and each of these radii or spokes carries a square porcelain part on which the hanks are placed. The porcelain parts revolve, moving the hanks round in the water, while the whole wheel moves round with a jerky movement in order to imitate the hand process of washing as nearly as possible. Thus the yarn is well and rapidly washed. The machine is supplied in three sizes with 12, 18, and 24 copper

radii, and is suitable for all classes of yarn. Such machines as these are especially suitable in the winter, when working with cold water is anything but pleasant.

Hank dyeing and washing are still principally done by hand, and at Chemnitz one may see workmen standing on the bridges crossing the river, and washing in the running water hanks which have been dyed. This peculiar sight may be witnessed all along the winding river. In the Barmen district such a practice is prevented by the bad state of the river, for only on a very wet Sunday and when the factories have been closed some hours can the Wupper be considered worthy of such usage.

Cloth dyeing is done on the jigger or in the rope form. I found big works abroad using both methods. The dyeing of cloth after mordanting was often done in the rope form, because then the mordanting ensured evenness and made the jigger unnecessary. Also, dyeing connected with printing was often done in that way. Ordinary cloth dyeing was generally done on the jigger, but the padding machine is becoming largely used.

For the rope form the dye beck contains a wooden frame on which pegs are placed; the ends of many pieces are sewn together, and the endless strand of cloth is sent spirally over the frame and through the dye liquor. The pegs prevent entangling. It is a regular thing to see a row of such machines in Germany, and they require little attention. As with jiggers, the difficulty of washing such machines makes it almost necessary to have different machines for different colours before good results can be obtained.

Besides the ordinary jiggers, which are everywhere in use, the Germans have also jiggers with extra rollers, the passage of the cloth through the liquor thus being made longer. The advantage of this is difficult to see, because the apparatus is harder to regulate, and the dyeing is really done more in the batch than while in the liquor.

In the batched-up state the fixation of the dye is effected, since the passage through the liquor is very quick.

In washing, the saving of water is of primary importance (page 25). At Chemnitz, as before stated, they use the river, and this is also the case at Mülhausen. Thus all the works congregate about the rivers. At the latter town I saw washing machines built over the river, the water of which acted for what is usually the base of the machine. The water, being fairly soft and clean, is suitable.

CHAPTER II.

COP DYEING.

Its object—Selection of colours—The difficulties involved—Machines of two classes—Comparison of these machines—Three important machines—Perfection not attained.

Until comparatively recently cotton had to be dyed in the shape of a hank—the cop was made into hank form, dyed, and wound back for placing in the shuttle. During this operation of unwinding and rewinding, cotton was lost because of the entangling of the thread. Cop dyeing arose to dispense with these operations, and thus to save both labour and material.

There are many machines for cop dyeing on the market, but the selection of proper dyestuffs and the proper handling of these machines are important factors in the success of the operations.

In the dyeing, the liquor has to be forced through the cop, and in this way the material of the cop must act as a filter for the dyestuff. For that reason only perfectly soluble colours and those leaving no residue in the dye bath can be advantageously used. Others cause unevenness and concentration at the points where the liquor enters the cops. This is partly counteracted in some machines by sending the liquor alternately in reverse directions. Consideration shows us that many colours, as aniline black, turkey red, etc., cannot be dyed with success on cops and others, as indigo are difficult to manage. The dyeing with sulphur

colours is also difficult because if the colours come in contact with the air during the action they oxidise on the top of the cops, producing unevenness. In using these colours the cops must be kept immersed during the whole dyeing operation. In order to get even penetration colours which dye slowly are used, and uniform dyeing with basic colours, which act quickly, is difficult. To overcome the difficulties various precautions have to be taken and the colour firms give every assistance in that direction by their carefully prepared recipes. Moreover, in cop dyeing, the dyer can never tell whether uniformity exists or whether he is sending black cops with white cores to the weaver. If the latter is not observant a whole piece might be spoiled in this way.

The machines for cop dyeing are of two classes:—(1) with solid spindles, (2) with perforated spindles.

In the first case the cops are packed together in as uniform a mass as possible, and the success of the operation depends on the homogeneity of this mass when the dye liquor is forced through. The packing is done by means of cotton waste and other such material, and steam is first sent through.

The oldest of these machines and the simplest is the Mommer machine, where the cops are tightly packed in a square box with two perforated sides and, by means of a pump connected to these sides, dye liquor is sent, first in one direction and then in the other. This alternation ensures more even penetration, for channels which may be formed in one passage are not likely to be formed when the dye is pumped in the other direction.

In Cohnen's machine, the only machine of this class that I saw at work in Germany, we can hydroextract directly, because the dye box is capable of revolution. We can dye, wash, and hydroextract without taking out of the machine. This is of importance in dyeing with basic colours, for it is necessary to hydroextract after each

process if unevenness is to be avoided. The Obermaier is also used, but interest in the solid spindle machines is rapidly falling, and attention is being turned to the improvement of the other class. The machine of Schirp, of Barmen, was seen dyeing with the solid spindles, but this machine can be used for either solid or perforated spindles as explained later.

The penetration with the second class of machines is more even, and this factor has decided in their favour. Also the power required to drive or suck the liquor is less. Formerly there was the difficulty of transferring the cop to and from the metallic spindle, since any mistake would easily spoil the cop, making it unfit for use. But now perforated paper spindles have been introduced which remain in the cops during all operations and keep the threads in order. The metallic spindle is placed inside this, and, after dyeing, the cop, along with the paper interior, is taken to the hydroextractor.

One case of uneven dyeing came to my notice which was difficult to account for. The inside of the cop, immediately next to where the paper spindle had been, was more deeply dyed than the remainder, and investigation showed that the alum which had been used in finishing the paper had acted acid to the dye liquor, drawn the dye stuff from solution, and concentrated it on the part of the cop immediately next to the paper.

In the case of the perforated spindle machines, the direction of the dye stuff is reversed as in the other case and for the same reason. Also if any impurities or solid particles of any kind are in the dye liquor they, rising to the top of the liquid, tend to fill up the top holes of the spindles, thus tending to produce cops unevenly dyed at the tops.

Of the modern perforated spindle machines we have (1) Haubold's, (2) Schirp's, (3) Pornitz's. Grämiger's was one of the first of this type, and of late it has been placed on the market for the dyeing of indigo.

I had the pleasure of seeing Haubold's machine at work in the establishment of Herr Haase, its inventor. This färberei is at Neukirchen, a few miles over the hills from Chemnitz, and, accompanied by a guide (kindly lent me by one of the colour firm's Chemnitz agent) I set out to walk on an extremely cold December day. The journey was arduous, but we did finally arrive to find Herr Haase surrounded by piles of cops and stockings. Chemnitz has a large and increasing business in the dyeing of stockings. The cop dyeing machine consists of two parts:—(1) a tun-dish-shaped dye-bath, and (2) a receptacle for the dye-liquor. The former part has a perforated bottom inside, and in these perforations the spindles carrying the cops are screwed. The bath is connected through a pump to the second part of the apparatus. The pump sends the liquor through the cops, almost filling the dye bath, and then, by reversing, some liquor is sucked back into the dye receptacle until the liquor in the dye bath just stands above the tops of the cops. The cops are thus kept wholly immersed, and many alternations of the pump ensure even dyeing. These passages of the dye, first in one direction and then in the other, take place about twenty times during an hour, according to the nature of the dyeing. If four machines are run together, as I found to be the case at this works, one engine suffices for all; but with one machine only the initial cost of driving becomes relatively higher. A machine costs about 12,000 marks (£600), and was first built 13 years ago. The inventor said it was the first and is still the best. It certainly seemed very simple and effective. Cotton and wool cops were being dyed, and the products stood minute examination. After dyeing, the cops were placed in small baskets, and arranged in a circle inside a hydro-extractor. After hydro-extracting they were dried in a heated chamber. To ensure good drying, a strong current of air is passed through the chamber, because otherwise the top side of the cop would dry first,

extract the dye liquor from the other parts, and thus produce unevenness.

The Schirp machine is likewise simple. It consists of a stout box with removable sides, in the middle of which fits another box which might be considered as a longitudinal section of the larger one. On both faces of the smaller box there are perforations into which the spindles carrying the cops fit, so that the spindles project into the space of the large box. The small compartment is connected to the dye liquor by means of a pump, and the liquor is forced through the cops into the larger box and away again in circulation. As before, paper spindles are used inside the cops and, when all is arranged, the small section charged with cops is wheeled into its position. The direction of the dye liquor is reversed from time to time for the reason before stated.

In the Pornitz machine we work both with suction and pressure. First we suck the liquor through the cops from the outside, and then press it through from the inside. The cop carrier is in this case a perforated cylinder, the cops taking up the whole of the round surface. The paper hearts of the cops fit on metallic spindles as in the other case. The charged cylinder is lowered by means of a chain into the dye-bath (a cylindrical vessel big enough to admit the cops) and, by means of compression and suction, the dye-liquor is made to pass between this dye-bath and the dye-reservoir. While the liquor is in the second receptacle mentioned, more dye-stuff can be added, and in this way slow and even dyeing is assured, whereas in the machines with continuous circulation, the addition of dye-stuff is difficult. The suction and compression are performed by means of a double-acting air pump. The machine can also be used for dyeing warps, these being wrapped round the cylinder of the machine. This is one of the most successful machines. It is very similar to the Haubold, and, having all its advantages, is also more

compact. The dye reservoir is usually placed underneath the dye-bath, and thus the whole machine takes up little space. It struck me as being the best of its kind.

In all these machines the cops have to be steamed and hot water sent through them before dyeing, in order to ensure even penetration.

At one works I saw a cop-dyeing machine in which the cops were tightly packed in a tall tower, and a little dye-liquor, placed at the bottom, was made to froth up by means of steam. A little soap was mixed with the dye-liquor, and when the bubbles burst the air particles round the fibre are driven away and the dye-stuff attracted by the fibre. This method did not impress one, and can hardly be considered of commercial importance, although it is said to be used successfully for dyeing certain shades on cheeses.

I saw no cop dyeing in America, and no Obermaier machines in use for dyeing raw cotton. Cop dyeing is too delicate and difficult a process for the Americans.

One remarked that nearly all the cop dyeing machines in Germany were similar—at least in principle,—and patents seem to have been ineffective. This is apparently the reason why nearly every firm has its own modification, and why the production of the machines for sale is, as yet, undeveloped. I called on Mommer, of Barmen, who said they no longer build their machine because there is little demand for it.

During the last year the dyeing of cops has not been much developed and, in spite of great attention, perfect penetration has not been attained. The Obermaier is good and cheap for loose wool, but the dyeing of cops with it is difficult, and various results have been obtained. The Theis apparatus is being much used in Westphalia and Holland for the bleaching of cops, and dyeing with it is also said to be satisfactory. The machines remain something the same, old types being improved upon from time to time and placed on the market.

CHAPTER III.

SULPHUR COLOURS AND INDIGO.

Development and importance—Methods of use—Temperatures used in dyeing—Machines used—Sulphur colours in the U.S.A.—Indigo dyeing.

The first of this series was Cachou de Laval, but this was not of great practical importance. In 1887 Green prepared primuline, and Vidal followed by making a black dye-stuff by a similar method. Since that time many other colours have been invented, until now these colours are termed "the colours of the future." They are comparatively new to dyeing, and new colours are continually being put on the market. Their brilliancy, deepness of shade, fastness and cheapness, have created quite a revolution in the dyeing industry. Cassella's sulphur blues are well-known colours, and the Hoechst thiogen violets are bright clear tones. The latter firm claim, in their thiogenpurpur, the first red sulphur dye-stuff to be put on the market. Its discovery was epoch making, but it is said that this product is not fast, while other firms are said to have as good products which they do not deem worthy of placing on their lists. Last year Kalle and Co. brought out their Thioindigo Red, which, unlike the other product mentioned, is very fast. This was *the* discovery of the year in coal-tar colours. The Basle Society of Chemical Industry followed with another red sulphur dye-stuff.

There is plenty of room for research and the colour firms are not idle, for during the past year the main progress

in coal-tar chemistry has been in the way of sulphur colours. Especially in sulphur blacks are things brisk, and one firm has turned out three specimens of these during the last two years. All firms are bringing out brands of great purity and concentration, fast to exposure. Their beauty of shade is beyond dispute and only in fastness to bleaching do they fail to compare with aniline black.

Yet these colours are liable to tender the fibre, and this fact has kept them from assuming an even higher position. The tendering does not necessarily take place immediately, but after a year the cotton may become quite rotten. Research points to this being due to the development of sulphuric acid, while copper and iron salts accelerate this change by contact action. Therefore coppering should not be used . Chroming is recommended, but many dyers object to this, saying that it is costly, entails further washing, and alters the shade. Leaving a little sodium acetate in the cloth is practised in Germany, and is said to give the desired effect. Any sulphuric acid which is developed then acts on the acetate, liberating acetic acid which is harmless. This has been known for years in England, but for some reason is little practised.

Sulphur colours are reduced by sodium sulphide, the material impregnated with the reduced mixture, and then the cloth allowed to oxidise in the air. In the oxidation there is often a change of colour. The dyeing takes place at high or low temperatures, according to the circumstances. Dyeing in the cold is only carried out when there is no steam available, but on the other hand a low temperature is preferable, since slow oxidation results, and therefore more uniform dyeing. The dyeings are certainly paler at low temperature, but this gives no loss, for less dye has to be added to make up the bath. Different brands dye at different temperatures, and the best conditions have to be found out. Many blacks dye best just under the boiling point, yet 60°C. is sometimes enough. Below this

temperature a fairly strong bath is required to produce normal dyeing. Fastness is a little better at high temperatures, but low temperatures preserve the cotton better. For light shades 30°C. is often enough, while some of the indigos may be advantageously dyed cold. The amount of sodium sulphide is also of importance, as the amount sufficient for the reduction does not always succeed in fixing the dye-stuff. As in other classes of dyeing, directions must be adhered to or peculiar results will be obtained. I saw a case where quite a rough "feel" was given to hanks because a mistake had been made.

For dyeing with these colours the machine I found most used was the ordinary jigger, the cloth being wound many times through the air after dyeing, to ensure oxidation. But successful dyeing depends on avoiding contact with the air during impregnation. Otherwise undesirable, bronzy precipitates, are produced. For the same reason boiling is not to be recommended, as the same precipitates result. Jiggers, in which the cloth is wound backwards and forwards under the liquor, and then squeezed before passing into the air, were in use. In all cases the cloth was squeezed before oxidation in order to produce evenness. The addition of a little glue to the bath prevents bronzy patches and thus assists the dyeing on the jigger. The dyeing of hanks is done by hand, or sometimes, I found, in the Klauder Weldon machine. Cop dyeing is perhaps best done on the Pornitz machine. The dyeing of sulphur colours is only in a primitive stage, and as in their manufacture, big changes are probable.

Whenever possible padding is better than dyeing. It is sometimes more expensive, but the greater evenness produced often outweighs the extra expense. Every dyer knows the difficulty of even dyeing, but in cases of mordanting and developing dye-stuffs on the fibre the difficulties are many times increased. Tannic acid divides itself fairly evenly over the fibres, and impregnation in

this case is easy; but in treating with some of the chromium mordants and other agents difficulties arise. Tannic acid can be fixed in the wet state, whereas some agents must first be dried evenly on the cloth. Difficulties of this kind have led to the introduction of padding, and I found this process often in use in Germany and America. Mordants were often padded, and then the dyeing done on the strand dyeing machines. In padding, the cloth is passed through the liquor to be padded, and then squeezed evenly by a pair of rollers usually made of brass and india rubber. One runs the cloth through the liquor and immediately squeezes as evenly as possible. From the squeezing rollers the cloth is easily batched up and conveyed to the drying apparatus or is plaited down and then taken to the drying apparatus. Slop padding is different from padding in printing, as it is like printing all over.

Padding with sulphur colours is difficult, because dyes for padding must be freely soluble. No copper or brass rollers may be used with sulphur colours. On the Continent I found glucose used for mixing with these dyes to produce the padding mixture. It is employed because of its reducing properties, but being dear, it renders the operation costly. When well padded these colours are as fast as when direct cotton colours are used. The process is only in its infancy, but is coming to the front, for padding is replacing dyeing.

Printing has also been begun, Cassellas having introduced their printing paste for printing sulphur colours mixed with caustic soda and glycerine.

Sulphur colours have got a firm footing in the States, and the German colour firms have exploited them well. One firm, whose representative I found going round American mills, has sold a million pounds of colour and has had a long run with sulphur blacks. The introduction of these colours has led to changes in the machinery in use; copper linings have been done away with and also in

other ways have the machines been adapted. Some mills claim to have the best sulphur dyeing machinery, but whether this be so or not cannot be determined, since they will not put it on view. Representatives of colour works were not allowed to see the machine, and these gentlemen found themselves in the peculiar position of giving instructions and seeing the firm's servants oscillating between themselves and the dye house. The Klauder Welldon machine, much in use in the United States, has been adapted for sulphur colours (see page 56).

The dyeing with sulphur colours is similar to indigo dyeing. In the dyeing of indigo, similar methods to those used at present have been in use for many years. The indigo is reduced by various reducing agents, the cloth impregnated with the reduced product, and then the indigo allowed to be regenerated by oxidation. Indigo is a pigment and, being finely divided, adheres to the cloth. In hank dyeing, impregnation takes place in a prepared vat which has been allowed to settle, the hank being squeezed or wrung out and then exposed to the air. The vat is gradually exhausted, and many vats of greater and greater strength are used in rotation until the desired effect is obtained. Similarly, in warp dyeing, we have this succession of vats, first a weak vat, then exposure to the air, then removal to a stronger vat, and so on. The hexagonal, spider-web-like frame is much used for piece goods in Germany, and also jiggers, which keep the cloth under the liquor during rotation. In another vat largely used the cloth is plaited down in a semi-circular channel, which is made of iron and placed in the indigo vat. Before the cloth emerges into the air it is squeezed in order to produce evenness.

CHAPTER IV.

MERCERISING.

What mercerisation means—Machines used—Mercerising of loose cotton and yarn—Economy of soda lye—Warp mercerising—Mercerising of piece goods—Economic washing—A machine for fine pieces—Mercerising business in Germany.

MERCERISING is a process of treating cotton with soda lye in order to give it a silky lustre and feel. The effect is not merely produced by the action of the soda on the cotton, but either (1) the cotton must be kept stretched during the action, or (2) it must be stretched to its original dimensions after the action. The soda causes the cotton to shrink considerably, and in resisting this shrinking force the lustre results.

Mercer invented the process in 1848, but he and his process were forgotten until Lowe and Thomas and Prevost in Crefeld discovered the same thing. There was great competition to obtain patents, but many of these were declared void in the law courts. This is no place to discuss the theory of the action during mercerising, the reader being referred to Hübner and Pope's work, recorded in the Journal of the Society of Chemical Industry; but suffice it to say that experiment has shown what is the best strength of caustic soda to use, and the best temperature at which to use it. Weak caustic is almost useless and temperature has a great effect. A good lustre can be obtained at 80°C., but most works have cooling apparatus

for the soda, for the advantage of cool mercerising comes in the cost, since it enables one to work with weaker soda. Soda of 55°Tw. and a temperature not above 65°F. are considered the best conditions. Numerous patents have been taken out for adding different substances to the caustic soda to increase the shrinkage produced in the cotton, but all of these have proved worse than useless, and progress in the art has turned to the mechanical rather than to the chemical side.

In all the machines the question has been one of opposing the force which tends to make, or actually makes, the material shrink. If this shrinkage takes place then little lustre results, although subsequent stretching produces the properties desired.

Cotton is mercerised as (1) loose, (2) hank, (3) warp, (4) piece. The mercerising of loose cotton is only in an experimental stage, different means having been suggested for preventing shrinkage during treatment with the lye. Rubber rollers were first tried as grips, and a few years ago Hübner and Pope invented a means by which the sliver is coiled up with wire gauze and thus gripped. This is placed in a centrifuge, and caustic sent through. The sliver mercerised in this way can be afterwards spun into yarns which could not be mercerised direct because of their weakness. I did not come across any machines for this purpose on the Continent.

In yarn mercerising there are many machines, and the comparative efficiencies of these are difficult to determine. The principal ones I saw in Germany were (1) Kleinewefer's, (2) Haubold's, (3) Bemberg's. The Kleinewefer mercerising establishment is said to be the largest of its kind in the world. Here they mercerise hanks with their own machine, which acts on the centrifugal principle. It consists of two parts, both being exactly the same, and joined together by the shaft which drives the parts. There are two metallic drums, containing two concentric per-

forated cylinders, round the inner of which the hanks are drawn. Three hundred kilos. of hanks are thus placed in each drum and made quite fast together. The faces of the two cylinders are then fixed and with them two pipes which supply caustic soda to the inner perforated cylinders. At the same time the inner cylinders are made to revolve, and the centrifugal force produced causes the caustic soda to pass through the perforations of the cylinders, through the hanks into the outer drums and back to the cisterns from which the caustic came. The inner cylinders, being stoutly built, resist all shrinkage of the hanks, lustre thus resulting. The pipe is then disconnected from the caustic, and water substituted to wash the hanks, which are further washed by hand on sticks before drying in the ordinary way. The wash water is used for dissolving caustic, while the caustic runs from the many machines in the room into a common trough and thence to a huge reservoir, where its strength is kept up. Here we can only use one size of hank to each machine, but all qualities can be treated in this way without risk. I saw very fine counts being given a really splendid lustre. The passing through of the caustic takes five minutes, and the economy of lye is good,—a consideration which is of the utmost importance in mercerisation. The hanks were being mercerised before bleaching, when I was there, and no doubt the treatment with caustic assisted in the subsequent bleaching operations. The whole process struck me as being simple, cheap, efficient and quick. Messrs. Kleinewefer informed me that they are not allowed to sell their machine in England.

The Haubold hank merceriser I found very much in use in Germany, particularly in the Chemnitz district. This machine consists of two sets of heavy stretching rollers over which the hanks are placed. The rollers are made to revolve, taking the hank round with them, and then the lower roller is placed in a trough containing caustic soda.

The hank revolves through this, is acted upon, and also prevented from shrinking by the power of the heavy rollers. Water is then spurted against the hanks, and in this way good results are obtained. To economise caustic soda the upper roller is provided with a squeezing roller to send as much caustic as possible back into the trough after it has done its work on the hank. The machine is made very massively in order to stand the great shrinking force exerted when pounds of hanks are on the rollers. The machine is made with twelve pairs of rollers, and has a capacity of from 500—1,800 pounds of yarn.

Bemberg's have supplied their hank merceriser to Germany, France and Italy. It was very much like Haubold's in principle, the hanks being stretched on heavy revolving cylinders. But there were four tanks or troughs, each containing two pairs of rollers, these tanks being connected with one another and with the supply of caustic by pipes. By means of a screw the distance between the stretching rollers could be altered and then the machine made suitable for all sizes of hanks. In that respect it apparently had the advantage of the Kleinewefer. Also it did not seem so massive as the Haubold. Mommer, a man well known as an inventor in the dyeing industry, held forth the claims of their (Bemberg's) machine, and easily outweighed me urging the claims of the Kleinwefer.

I also saw a very efficient American merceriser suitable for large works. Stretching is done in the same way as in the Haubold, but in this case the stretching rollers move along, the upper and lower sets describing endless paths while carrying the hanks. The hanks are put on the rollers at one end of the machine, spurted with caustic while passing through the machine, and taken off when they get to the other side. The machine is the same back and front, and its removable glass sides show what is taking place within the machine. The driving is very powerful. This machine is suitable for the American

market (where large quantities are treated), but adapted for few of our works. Hanks are continually being put on and taken off the rollers, so that to ensure economic working large quantities must be treated.

With high perfection in these machines inventive skill now turns to the saving of caustic soda. The hanks are well squeezed by auxiliary rollers, as before stated, and then washed by counter currents, the solution being used afterwards to dissolve the caustic.

The mercerising of cotton warps is done either on the warp dyeing machine, producing tension by allowing one set of rollers to go faster than the other, or very easily on the warp sizer or slasher.

Machines for piece mercerising are divided into two classes—(1) in which penetration is carried out on one machine and stretching on another, the cloth being allowed to shrink first and then stretched to its original dimensions, and (2) in which we impregnate, allow the cloth to shrink as little as possible, and stretch right away on the same machine. As to which is the better method there is some dispute, and good lustres can be obtained by both. By the former method, however, more power is required in stretching, and breakages are therefore more frequent, because after a proper shrinkage stretching to the original width in the grey is risky. At first many machines were invented for gripping the cloth in different ways and preventing it from shrinking. In one case the cloth, after immersion in the caustic, was passed over a series of squeezing rollers which were rubber-covered, and so arranged that the cloth was always in contact with one or another of them. Since the rollers tightly pressed and held the cloth it could not shrink. Another machine holds the cloth in a similar way all the time it is in the caustic; but with both methods, if you pass in cloth 27 ins. wide, it will not be that width when it comes out. If we wish to get the cloth to the original width the stenter has

to be requisitioned, and then the question arises—why not use the stenter right away? Very often cloth has to be turned out by the merceriser at the original width, or at least at some definite width, and this necessity has led to the almost universal adoption of the stenter for piece mercerising.

At Bemberg's of Barmen the piece mercerising is considered to be excellent. At one time an English firm of mercerisers perceived this, and by a roundabout way succeeded in getting some cloth mercerised there. The method of " batching up " is used, the cotton being passed through the caustic and made into a big tight batch. After being allowed to stand a short time it is removed to a stenter close by, passed through, and at the same time washed. The goods do not lose in length and width, and with their clips it is claimed that there is no danger of damage at the edge. In separate tanks you wash, acidify, and wash again, the first wash water being used to make up further caustic soda. The machines are made in various sizes, and with a horse power of six they claim to mercerise 16,000 yards in ten hours. There is a very large plant attached for cooling the caustic. Although they claim special advantages for their clips yet I found Mather and Platt's acknowledged as good as any in Germany.

The principal item in all washing arrangements is the saving of water. Therefore, to do this, the washing is usually done on the principle of counter currents. It is like a current of impurity meeting a current of clean water, and is the most effective method. The stuff meets cleaner and cleaner water until it comes into contact with perfectly clean water and emerges washed. Dirty water meets dirtier and dirtier stuff, until finally it is saturated and run to waste. Thought has proved the best of economisers, and all should be acquainted with principles of this kind. It is used in crystallisation, in many chemical operations,

and (nearer home) in some drying machines. These machines are best constructed so that the driest goods are exposed to the hottest air, the current of water meeting the current of heat, so that the greatest heat is requisitioned in expelling the last traces of moisture. This gives the most economical drying.

Turning again to mercerising, on page 47 will be found an account of a mercerising plant in use in the United States.

Because of the high tension produced by the action, the mercerising of fine counts is still very difficult. It is evident that the stenter has to be used with caution, and the use of pins to grip the cloth has been suggested. On first thought this would seem impracticable. Yet I have seen a machine at Koechlin Frères, Mülhausen, turning out five miles a day of very fine mercerised muslin. Instead of clipping at the edge and stretching right across the width, the machine mentioned grips the cloth by means of pins arranged all over the round surface of a cylindrical drum. The cloth passes through the soda lye and then on to drums provided with the pins. One would think that the pins would have a damaging effect on the cloth, but this was found not to be so, at least in the case of the cloth I saw in passage. After passing over three such drums the cloth is washed in the usual way. These machines are at work in Germany and in America. The process is very simple and effective.

The returns for Crefeld and district show that the business of mercerising is not increasing, and that they are losing some of their markets. The export to the United States has fallen off, as the Americans are now mercerising their own, often buying their yarns from England. At the same time, South America and East Asia have, by increased demand, partially made up the deficiency. Competition in all quarters is lowering the profits in this branch of the trade.

CHAPTER V.

BLEACHING.

Development of the process—Progress on the mechanical side—Closed kiers—Open width bleaching—New methods of bleaching—Substitutes for bleaching powder—Electrolytic bleaching.

Bleaching is now a very different process from what it was in the eighteenth century. At that time it required a period of several months to bleach a piece of cloth and this, too, only in the summer time. In some cases the cloth was sent in the spring to be bleached on the level grassy plains of Holland and returned in the autumn. Our linen manufactures went there to be steeped in potash lye, washed, steeped in buttermilk, and then laid out on the grass for several months. A process very similar next became established in this country, the goods being still several months under process of bleaching, but the transference to and from Holland being no longer necessary. Then arose the improvement of substituting sulphuric acid for milk, whereby the same effect was wrought in one day which before occupied six weeks, and brought the whole bleaching process within a period of three or four months. Later the discovery of the bleaching properties of chlorine led to Berthollet practically applying this gas in 1790 to the bleaching of textiles. Next, this method of bleaching by chlorine gas was introduced in England and Scotland. How to confine the precious gas was the problem, because the gas itself was highly deleterious to the workmen, and

its solution of a very offensive odour. It was at first absorbed by potash, then by milk of lime, and finally Tennant used slaked lime, producing a dry powder capable of easy transport, without the offensive odour yet containing all the properties of the chlorine, and procurable at a cheap rate. Thus we had a shortening of the process from eight months to a few hours. This is one of the best examples of the application of chemical science to manufacture.

During the last century, the system of bleaching has undergone few changes, although the details have received attention. Improvements have taken place, yet the processes of washing, liming, grey souring, ashing, chemicking, souring and washing remain somewhat the same. Attempts have been made to do away with the long scouring process and chemical boiling agents have been introduced, but they have been badly received, and the methods which have served England so long are likely to serve still longer.

Progress has been made principally on the mechanical side, great improvements having been introduced here. Machines have enabled cops to be bleached, besides securing the more effective bleaching of loose materials.

Proper scouring is essential to good bleaching, just as good bleaching is essential if even dyeing be subsequently desired, and efficient boiling is perhaps the most difficult of the bleacher's duties. All bleachers know the difficulty of obtaining a really effective thorough circulation of the lye through the mass of the fabric in the kier. Even in the best constructed closed kiers the liquor endeavours to force itself along the walls of the vessel where the mass of cloth is less tightly compressed and consequently offers less resistance. The remainder of the mass is not so well treated, and the result is that the bleach is lacking in uniformity. It is obvious that those parts lying in the direct path of the circulating lye will be bleached first, while those lying very remote will stand a poor chance.

If, therefore, the boiling of the charge be interrupted after a half or one-quarter the normal time for the operation, instead of the whole quantity of cloth being found to be in a uniformly cleansed condition, parts will be found perfectly cleansed, whilst others are less so, and finally there will be parts which are only superficially attacked by the lye. For this reason it is necessary in closed kiers not only to employ a higher temperature in order to obtain uniform bleaching, but also to prolong the time of boiling for several hours, whereas for the complete transformation of the impurities of the cotton one hour should suffice.

Various kiers have been introduced to ensure evenness in the treatment, and some of these have met with success. Some have a perforated pipe down the middle and also a perforated cylinder a short distance from the wall of the kier. Between the perforations of the pipe and cylinder the lye passes through the goods. Kiers of this type I saw in construction at Haubold's, of Chemnitz, and Gebauer's, of Berlin. With injector kiers there is the difficulty, if the contents boil at a high temperature, of getting steam into the injector. This causes intermittent working, and thus uneven bleaching.

In the Walsh Jackson kier, which is largely used at the present time, circulation is produced by means of a powerful centrifugal pump. The lye passes from the bottom of the kier into the pump and then to a cylinder containing a coil supplied with high pressure steam, where it is heated up and forced back into the kier. The lye is heated very quickly, and the powerful pump produces thorough circulaton.

In all the kiers, the principal disadvantage, as before stated, has been uneven penetration, for in a kier containing two tons of cloth, the lye has to travel through many layers. This has led to the introduction of scouring in the open width. The cloth is treated right from the singeing in the full width. Thus uniformity is secured, the im-

portance of which cannot be over estimated. Usage in the rope or strand form is productive of irregularities, and the rubbing of the strand against objects in the way has been found to injure the material.

Many types of apparatus have been devised to bleach in the open width. The greatest difficulty has been experienced in constructing a kier in which the cloth is treated full width continuously, and in which the pressure in the kier is held up during the passage of the cloth in and out. An arrangement is required to let out the cloth and retain the steam. There are two types of kier:—(1) Those employing a seal of this kind, and (2) those not having such a seal.

The Edmeston, which was the first of the kind, consists of one large tank open at the top, into which another tank is placed open at the bottom. Steam is admitted into the inner one and, causing a head of lye in the outer, provides the seal required. The cloth is passed through the lye, between the wall of the two tanks, into the lye of the inner tank, and then, by means of rollers, through the steam, into the lye again, then into the steam and finally out through the seal of lye. The alternate steaming and lye boiling is very effective. The machine works at from 30 to 50 yards per minute. The pressure is not very high; but it is questionable whether this is necessary. The general belief is that a high steam pressure kier is much more effective, the high pressure being held to induce a high temperature, and consequently a more rapid and thorough transformation of the substances contained in the cloth. This is true, but it does not follow that a good bleach cannot be obtained at low pressures and temperatures. The reason why kiers are run at high pressure is not that this is necessary for a good bleach, but, in order to oppose the main defects of closed kiers, viz., want of movement.

The Tagliani Rigamonti is another kier of this kind.

It was invented by two Milan chemists and the patent rights have been secured by Bemberg's, of Barmen, where I saw it at work. It resembles the Edmeston, except that we have one seal instead of two. The cloth, instead of going in at one side of the apparatus and out at the other, returns by the same opening. The chamber is similar to the Edmeston, the pressure of steam creating a head of lye, but the cloth, instead of being conducted over a number of rollers, is plaited down between two endless chains which travel continuously over rollers. Between these chains the cloth is carried along, being at one time immersed in soda, and at another steamed. We have altogether (1) immersion in soda lye, (2) steaming, (3) soda, (4) steaming, and then passing out through the soda lye. The cloth here has not to withstand the strain of the numerous rollers of the Edmeston, there being no strain on the cloth when passing between the chains. The working of these chains suggests complication, but devices have been introduced by the inventors to ensure against mishaps. The apparatus takes up very little space, and has a big capacity for its size, since a great amount of cloth can be plaited between the chains. The liquor is kept thoroughly circulated by means of a pump, being sucked from the bottom and spurted on the cloth from the top. It is claimed that the apparatus can take up from 2,000 to 8,000 yards of cloth and as, according to the nature of the cloth the same remains in from 1 to $1\frac{1}{2}$ hours, therefore in 10 hours from 20,000 to 50,000 yards of cloth can be bleached.

If the cloth is heavy and contains a large number of impurities, then this method of bleaching is not to be recommended, but it is good enough for most purposes. As in dyeing we do not want the best and fastest of dyestuffs in all cases, so in bleaching a perfect bleach is not always required. The disadvantage of stopping the ordinary boil before it is finished has been mentioned on

page 29, but apparatus after the nature described may suffice where only a partial bleach is necessary. If it was not for the capital to be invested in plant, one might conceive of different bleaching plants existing in the same works and being used according to the special requirements in each case. Kiers of the nature described above are only new. In the case of the Tagliani it is claimed that the working is more economical than the ordinary process. The one I saw, together with a few in Italy, are the only ones in use.

In the Welter (Mülhausen) kier the inlet and outlet of the steam chamber are hydraulic traps, the first receiving the lye while the other serves as a washing box. Like the Edmeston it has small capacity for its size, even though the capacity has been doubled by running two pieces of cloth in together, that is, one upon the other. Also, the apparatus being large, it is necessary to keep the steam pressure low, and this is a big drawback.

Of the second system of open width kiers the Jackson-Hunt is the best known on the Continent. It consists of a horizontal cylinder open at one end, and into which the cloth is brought in the roll form. The cloth is then arranged so that it can be rolled off over a perforated cylinder and again batched up. During the passage caustic soda is run on to the top of the cloth and through the perforations of the cylinder. The soda is sucked from the bottom of the kier and spurted through the cloth again by means of a pump. When the cloth has run once over the perforated drum there is special provision in the driving gear for reversing and sending the cloth by the same path to its original position. Before winding and previous to boiling, a special machine is used called the saturating machine, in which caustic soda from the machine previously described is forced by means of steam into the cloth. The cloth passes over a large perforated drum placed in a tank of caustic, and the soda is given

access to the cloth by means of steam which is blown strongly against the surface. Thus wetted out, the cloth winds much more evenly and tightly on the drum, for upon these factors the success of the operation largely depends. Steam of 60 lbs. per square inch is used.

Gebauer, of Berlin, also builds a machine of this kind in which the cloth is saturated with caustic and wound backwards and forwards in steam.

The question of bleaching in the piece is as important as ever, but the cost of this is higher than ordinary bleaching. The apparatus of Welter, Tagliani and Muntadas (Paris) give good results, but the cost is the principal point, and bleaching in the strand form is very cheap. The Jackson apparatus is very good for heavy things. It is in every way satisfactory, the method simple, but the cost of the apparatus heavy. The question of reducing the cost is foremost. It is well known that new bleaching processes have not been well received. Conservatism is wrong, and perhaps even in bleaching, where the processes have remained substantially the same for years, a change is coming about. The ordinary system can certainly be improved, and possibilities of irregular bleaching lessened.

Pick and Erban work the cloth in 2 per cent. turkey-red oil containing chlor-soda. The oil lightens the work of the soda and acts as a cleanser. For three years this has been successful with cops and spools. It is suitable for loose material, mercerised yarn and light articles requiring little treatment. Nobody thought of using soap in scouring until the nineties, when Hertel used turkey-red oil to soak the cotton in, boiled with soda lye, rinsed, soured, rinsed, soaped at the boil, rinsed and dried. There were other modifications of this process and then we had peroxides, salts of alum, organic reducing bodies, etc., introduced for purposes of boiling. These, as stated previously, came to no large use. The addition of oil or fatty substances to the vat to prevent the chlorine from tendering

the fibre was suggested, but these only make the liquid more difficult to circulate and protected the fibres only at the expense of bleaching by keeping the bleaching agent from the fibres. To prevent unevenness in the scouring of the cloth, turkey-red oil or castor oil soaps with alkali hypochlorites have been suggested. Here the oil is in the soluble soap form and not insoluble as before. This has been found efficacious for cops.

Other bleaching agents beside bleaching powder have been introduced from time to time, and while some have not got past the experimental stage, others have met with favour. Ozone is a little used for finishing off after the bleaching powder has acted; Hydrogen peroxide in conjunction with soap, magnesia, and caustic soda in a boiling bath gives an excellent bleach on cotton, but the cost places it out of question; slightly acid permanganate is good for cotton, as also is the alkaline solution if sulphur dioxide be used afterwards to bring the goods from their brown to white colour.

Sodium hypochlorite solution has long been an article of commerce for use instead of bleaching powder. It is made from the latter by adding washing soda, thus precipitating calcium carbonate and drawing off into tanks the clear liquid containing the active chlorine. The precipitated sludge also contains chlorine and is used again.

The clear sodium hypochlorite solution is better than bleaching powder solution for many reasons. Being more soluble the solution is stronger and is said to produce a better "feel" on the bleached goods. The bleaching is more even because there are no suspended undissolved particles in the solution. No lime salts are deposited unevenly over the fibres, requiring prolonged souring and washing in attempted removal. For this reason the goods take the dye-stuffs more evenly afterwards. Then the sodium solution is much cleaner to use.

Bleaching powder is made in large quantities nowadays

by the electrolytic method. Brine is electrolysed and the chlorine evolved is led away to chambers containing slaked lime awaiting to be changed into bleaching powder. In the decomposition of brine hydrogen and chlorine gases, beside caustic soda, are produced. The hydrogen escapes easily and, if the chlorine be not led away but allowed to mix with the caustic soda, at low temperatures a most efficient bleaching liquor results. Electrolysers have been invented to accomplish this and thus bleach by the aid of brine and electric energy. The idea is to charge the brine with the important chlorine, pass it on to the bleaching tank and, when spent, back again to receive another charge. The circulation is accomplished in one machine (the Mather and Platt) by means of a centrifugal pump, whereas in the Haas Oettel apparatus it is produced by a means indicated later.

The first electrolyser of this kind was introduced about 16 years ago. It consisted of a platinum positive electrode and zinc plates held in a leaden frame for the negative. Other cells were designed containing sheet platinum for electrodes. It was found, however, that these expensive parts were too rapidly destroyed, sometimes in an inexplicable manner. Iridium was mixed with the platinum and found to increase the life of the plates.

Mather and Platt make an electrolyser which consists of a series of glass plates on which platinum-iridium wires are wrapped. These plates stand vertically and parallel in a shallow trough containing brine. The brine enters from a cooling coil, passes between the plates and out at the other side on its way to the bleaching cistern. From here it returns via the cooling coil.

In the Haas Oettel Electrolyser the expense of platinum electrodes is done away with, carbon electrodes being used. The body of the electrolyser is of special composition covered with insulating material, and is placed in a tank of brine. The cell has small openings, at the top and

bottom, communicating with the brine which is poured into the tank until it stands just at the level of the top openings. When the current is turned on hydrogen escapes vigorously, and in so doing gives us a method of circulation. The rapid evolution of the gas causes overflowing, the liquor passing through the upper tubes, and at the same time draws a corresponding amount of liquor in at the bottom. The power of the escaping gas produces not a mere trickling but a circulation which is sufficient for the purpose. The liquor is syphoned off and used for bleaching. The electrodes are completely submerged so that there is no danger of short circuiting over the top of the liquid. A slate slab being non-conducting also prevents the current from passing where it is not desired. The electrodes after a time become covered with deposit out of the salt and the efficiency of the apparatus decreases, but by reversing the current the normal state is reproduced. It is not advisable to let the temperature rise above 10°C., cooling being produced by a stream of cold water. One can electrolyse to 10 to 15 grams of chlorine per litre, while, with the Mather and Platt, the efficiency drops off considerably if 3 to 5 grams of chlorine per litre be exceeded. So with this apparatus a smaller quantity of brine is necessary, and the expense of cooling is therefore less. The electrodes certainly deteriorate, but they are not expensive. The apparatus has many advantages. Its initial cost is low; the wear and tear is small; and it is simple to operate. It was at work at the Cocheco Manufacturing Company at Dover, New Hampshire, the enterprising firm which is exploiting the Cell Dryer (p. 54). But the relative efficiency of these electrolysers is not known, because no disinterested comparison has yet been made.

Electricity is introducing cleanliness into manufacture, and with machines of this kind there are no odours of chlorine to make the employees miserable. Perhaps this

form of bleaching is a little more expensive than using bleaching powder (we have no reliable information one way or the other), but the external advantages pointed out, the better bleach produced by the most soluble bleaching agent, and the rise of electricity as a cheap source of power indicate a future for this method. For works which engage in bleaching on a small scale (considering bleaching powder if not used deteriorates) then from the advantages enumerated the electrolytic method ought to commend itself as apparatus of all sizes can be installed.

CHAPTER VI.

THE INDUSTRY IN THE UNITED STATES.

American conditions—Scarcity of labour—Large scale production—Their industry is uncertain—Lack of specialisation—Effect of the tariff.

We hear so much nowadays about American progressiveness and about employers smashing up old machinery to make way for new, that any information concerning the industrial position on that side of the "pond" is always welcome, still more so, indeed, when comparisons between our position and theirs are drawn.

My experience is that America has not much to teach us as regards the dyeing industry, except that it has different conditions, and possesses a few machines really worthy of mention. These latter have been devised in accordance with that old truth that necessity is the mother of invention for, as labour is scarce, means have had to be devised to obviate that difficulty, and in this way many mechanical devices have come into existence. Mills in New England cannot run to their full capacity because of the scarcity of labour, a scarcity which the enormous influence of foreigners does not seem to appease, for the poorest classes of labour cannot really be found, and in the summer months colour strainers and mixers are missing from the print works because of the smells of acetic acid, etc. The men would rather loaf about than work under conditions which the same class of labourer in England would be glad of. In the manufacturing town of Passaic,

New Jersey, which has a population of 35,000, they say they have people of every race (costumes of all nationalities are seen in the streets), while in the New England cotton mills the Irish labourers are being displaced by Hungarians, Greeks, French Canadians, etc.

As has been often pointed out the American cotton and woollen industries, and particularly their dyeing branches, are so different from ours that often different conditions and machinery are necessary. The American home market is so large and the demand for material so great that the manufacturers are not as particular as we are as to what they turn out. American people all wish to be well dressed, and as different seasons of the year demand entirely different clothes, there arises a huge demand. The calico printing done there is essentially that of the million, and the very best of stuff is either imported or made by a few concerns. As the head of one of the largest firms in New England told me " Here we print and dye a whole lot, put it on a train, and, sending it in the direction of California, it soon sells. America has a huge market, whereas in England you have to have certain designs for Egypt, others for China and so on. Further, the English business is surer. A man knows how much the grey takes for bleaching; how much for mercerising, dyeing, printing and finishing; and if he wants a turkey red he knows how much he has to pay the dyer. He knows he has to pay the printer differently for an albumen print than for a discharge. Reckoning in this way he can get the cost of placing the goods in his customer's hands and be assured of his profit; whereas with us, where we do the whole of the operation from spinning to finishing, we have to wait until some period of the year when the reckoning of the accounts tells us our fate. We aim at turning out the stuff cheap and quick here." Anybody arriving in New York has an opportunity the first day of gathering the nature of America's industry. Taking a ferry boat to Jersey City

and seeing the people begin to run as soon as they touch land, or watching the masses hurrying over Brooklyn Bridge in the evening, one has the industrial American epitomised——rush.

It has been said that the mills undertake all operations. Nor does the industry show much sign of modification in this respect. Instead of specialising we find the mills developing towards self-sustenance. For example the Gera mills, Passaic, New Jersey, have just begun to spin their own yarns, besides manufacturing a flannel, which is quite well known in the district. Yet some of the New England concerns are beginning to see the advantage of specialisation in their own rather highly developed market, and many managers hope for a time when they will receive goods to be dyed, etc., on commission, as is done here. Specialised bleacheries and dye works have arisen at Fall River, Lawrence, and other places, and English conditions have ensued at New Bedford in having separate spinning and weaving sheds. But such examples are few.

Further, the extent and homogeneity of their markets have led to the production of large quantities of the same material, and thus has brought many economies, besides making their industry of a particular and unique character. America is too occupied with her own development to think of export trade, nevertheless some of the New England mills make for export, the Arnold Mills, at North Adams, Mass., shipping some very fine prints. Although America's principal concern is for the home market, yet it has its eye on foreign markets and is making preparation.

With the change and increase in variety of human tastes everybody has sought the best of material, and this has led to a large class of good imitations in order to meet all comers. It is said that, in this class of work, we are behindhand, and, pointing to the foreigner, we are urged to adapt ourselves to the change of circumstances. This backwardness in imitation has not always been our failing,

for to the former possession of this trait in our character America owes much of the fame of her cotton goods in Eastern markets. Those in the Manchester business can testify how we employed china clay and other things in order to cater for appearances, and also (not merely incidentally) to save cotton. In the sixties we used to send goods to China, which contained more filling than they did cotton, and in some cases they were known even to crack. Things came to such a pass that finishers complained that adding so much stuff to the cloth ruined their machines in the treatment. These were the days of mildew causing rotting, for in those days an antiseptic had not been introduced. After the Civil War, American manufactures began to boom, and cotton goods containing only cotton were sent out. These soon made a name against our filled stuff, and American drills and sheetings became of world-wide fame. Nowadays we are sensible enough to send similar goods to compete in the same market.

The high American tariff has in many cases caused foreign firms to establish branches in the States, and to import the machinery, men and everything. In time some of these have become Americanised and gradually changed in character. The Gera woollen mills is a branch of the firm at Gera, Germany; the employers, machines, and methods being exactly the same as at the parent works. Titus Salts, of Saltaire, have a branch in Bridgeport, Connecticut, which is in a further state of development, having gradually become an American concern. Originally a branch of the Saltaire works making silk, mohair, and cotton plushes, it had English employés, whereas now only the principals are English by birth. Also linen thread mills have been established from England, Ireland, and Scotland, importing their flax ready for use from the parent works and so escaping the tariff.

CHAPTER VII.

LOWELL, LAWRENCE AND FALL RIVER, MASS.

Lowell—The town and its industry—Merrimack Manufacturing Co.—Hours and conditions—Turning to finer work—Production of machines—Employer and employed—Hamilton Manufacturing Co.—Arrangement of works—American worker—Lawrence and its industry—Pemberton Works—Pacific and Arlington Mills—Fall River—Water supply—Fall River Bleachery—The drying of cloth—Barnaby Works—Bleaching and dyeing—Bridgeport, Conn.—Salt's Manufacturing Co.—Klauder Welldon dyeing machines.

In Lowell the Englishman has little to wish for. It is brighter than English manufacturing towns, nicely situated in the country, and abounds in amusements of the best kind. There is also a splendid library and technical institute. The place has a population of 100,000, with 40 mills engaged in different branches of the textile industry. There is one specialised bleachery, but the dyeing, bleaching, and finishing is usually done by the big works themselves. Lowell is well connected by two services of railroad.

The Merrimack Manufacturing Company have the largest mill in Lowell and a capital of $4,400,000. They manufacture plain and fancy cottons; bleached and finished linens; towels, and corduroys; and have 140,000 spindles, 7,200 looms, and 21 printing machines. I had no difficulty in getting introduced to the manager of the printing

department, and in being shown all I wanted to see. He and his family were from Manchester, England, and thus well suited to help me in drawing comparisons. The firm willingly allowed people to go over their establishment. There was a combine of manufacturers allowing servants from all works in the combine access to each; and this, they found, worked very well. A man might get an idea by visiting a works in the combine, and he might use it to his advantage without in any way hindering the works from which he obtained his idea. This combination was only a pool of knowledge, and the manager thought it was the best way of working, since it was useless to attempt to keep secrets. Yet all the works do not grant the same facility to strangers, and some are becoming unusually strict and exclusive. There are two printworks in North Adams, and rivalry is so bitter that an operative of one is not allowed to talk on business matters with an employé of the other. This behaviour my entertainer considered nonsensical, and thought would surely be abandoned. I fully agreed.

He allowed no secrets in his department. All the finishing recipes, etc., are known to the principals, since they consider they know more about finishing their own cloth than does a finisher they have perhaps just introduced from abroad. They had a case of an indigo dyer who would not give full particulars, and who, on still refusing to be open, was expelled: now they have a man who adheres to their rules and at the same time is as good a dyer as his predecessor. How would they know what dye liquors were being thrown away if their servants were allowed to go on unrestrained?

Everything is worked on a scientific plan, a book in each department recording what is going on. The colour mixing forms a separate department, and no dyer is allowed to mix his own colour. Nor is he allowed to have anything to do with the buying of the colours, as is so often the

case in England and Ireland. The colours are given to him, and he is ignorant of what firms have supplied them unless he is told. My entertainer had never met a dyer yet who could mix colour. They added the dyestuff in pinches to the bath instead of taking the greatest precautions to ensure perfect solution.

They had a good strainer here in the colour mixing room. The printing composition was put into a big cloth, screwed up, and the end of the cloth brought through a hole in a plate which fitted over a vessel placed in readiness to receive the colour mixture. The end of the cloth is then fastened to an iron rod, and a man twisting this, draws the cloth through the hole, and thus forces the printing mixture through the meshes of the cloth into the vessel below. This is a very quick method.

This colour mixing room smelt strongly of acetic acid, and in the summer months there is great difficulty in getting men to work here. Indeed, this lack of labour is not only with the lowest class, as mentioned, but with all occupations. Part of the weaving shed at the works was shut down, and all complain that they cannot get hands enough. This is the case with most trades in America, and an American professor told me that he could not get a man to put a fence round a part of his garden. Yet in all the open spaces in such towns as Fall River, and particularly Lawrence, one can see men lounging about and escaping the work. Presumably they find some means of living without labour.

Returning to the Merrimack, we find the hands working 10½ hours a day, stopping at 12 on Saturdays. When I was there (June, 1906) this firm had the slackest time they had had for five years. The manager thought the most successful works were those employing the best hands, having things scientifically managed, and using the latest machinery. The Arnold Works at North Adams, Mass., is the best printworks in the country, and they turn out

fine goods which command a foreign market. They are old works which have specialised in fine prints, and are reaping the benefit. They specialise, employ the best hands in the country, have things well managed, and use the latest machinery. Only the firm with the latest machinery could survive in the long run, and if a firm is making big profits some of this should be invested to ensure even greater profits in the future. The best investment of this kind is by "scrapping" inefficient machinery and replacing it by the latest inventions.

Then he spoke of the advantages of specialisation, which he regarded as the true road to success. Schoenhof, in his "Economy of High Wages," pointing to the advantages of specialisation, said: "America is in front of England here. An English paper mill boasts of making 160 varieties, whereas an American mill confines itself to one, and whereas a Salford mill weaves many kinds of cloth, they (Americans) treat of few." As far as the textile industries are concerned, it must be said that we lead in specialised production. It is very true that in any branch of manufacture, for example, weaving, high internal specialisation exists in the United States, a works being known principally for one cloth; but at the same time what might be called external specialisation has to be considered. We are not so given to putting different kinds of manufacture under the same direction as they are in the United States.

They recognised at the Merrimack that they were going in for too many kinds of stuff. They were famous for their coarse cloths, having done these since 1823. They found that treating these and finer goods with the same machinery did not pay. The dirt and other things brought in, in the one case, spoiled success in the other. In their works there was a gradual tendency to the finer counts, and I saw some fine muslins and flannellettes there. This trade was more profitable and the price of cotton did not affect them so much as with the coarser cloths, where

the principal cost was in the cotton from which they were made. At one time the Southern producers combined, and would only supply a certain amount of cotton. This influenced their coarse cloth manufacture severely, and they had to shut down parts of their mills. Their industry is domineered by the speculators, as ours is.*

(1905) Mr. Gulline thought that if they took other people's cloth and printed it at so much a piece they might be more prosperous in his department, and obviously more certain. He was making an effort, and by gradually leading to the finer counts he hoped to make his place noted for fine prints. Although England has many more spindles than America, yet the latter country consumes more cotton. This is due to the fine work the English do. English yarn has been growing finer and finer, and whereas foreign countries produce their own coarse yarns, yet they rely upon us for the finer articles. Long training and hereditary skill, among other things, accounted for the position, and he thought time would bring England and other countries nearer together, certainly England and America closer, and, he hoped, Bolton and Lowell.

In the finishing department they had a machine for producing a slight mercerised finish. The cloth is passed through soda lye, batched up, allowed to stand, washed and then taken for further operations. Finally, after perhaps standing a day, it is brought to within half an inch of its original width on the stenter. In the treatment with caustic the cloth shrinks, and, instead of taking it right away to the stentering machine, as is usually done in mercerising, the other operations are proceeded with. The lustre obtained in this way is not so good as that by the ordinary process of mercerising, but yet the goods have

* I found the Germans affected in the same way. While I was at Chemnitz the people were much interested in the presidential election in U.S.A., as they considered this decided to a great extent the stability of the cotton market.

a very fair feel which ensures them a good market. The process is very cheap, as the lye is recovered, and three men supervise six machines, while the slight expense incurred is warranted by the increased profit.

They also have a large mercerising machine which is a combination of what they think is best on the market. It is built in their own shop, where they employ many men and make most of their machinery. This system of attaching machine shops to the works I also found in Germany, and shows how much more specialised conditions are in England. Those exploiting industries in new countries can speak of the aggravation caused by the lack of machine and other subsidiary industries, and to ensure success they have to build up these secondary industries along with their primary ones. But now specialised machine shops are arising in all districts of the States, and gradually conditions are coming to resemble those existing in England.

Again referring to the Merrimack's merceriser, the cloth passes through the soda, between rollers, on to the stenter, and is there sprayed with more soda from above and below. The stenter-frame widens out and stretches the cloth, which passes between another nip, and while the cloth is still stretched water is sprayed on. Treatment in washing and acid boxes follows. My informant thought it was difficult to say what was the best arrangement for mercerising, and that more work on the subject was needed. I referred him to the work of two Manchester chemists on the subject, and this he said he would peruse. He found he could mercerise very fine cloths on their machine without any danger of tearing.

They have a Birch (English) soaper and many copies of this machine which they have made in their machine shop; also a Mather and Platt aniline black ager, and some of the same firm's printing machines. They are gradually introducing their own machinery. This, indeed,

is the case all over, of copies displacing the foreign originals.

Beetling was done here at one time, but this was found too expensive a finishing process for their market. Their old stentering machines were shut in by glass and wood frames in order to keep the heat from the operatives, who would not work otherwise. These enclosures confine the heat, but at the same time do not allow the steam to escape from the neighbourhood of the wet cloth. In the newer machines I found our type, steam-pipes being placed quite near under the travelling cloth and the steam escaping freely on all sides to the roof. They had also the hot-air drying arrangement, but he said the steam-pipes were preferred. These pipes, directly under the cloth, are shut in from the outside, but the cloth above is quite exposed.

Few jiggers were used, padding being more practised. They have been doing a deal of para red (imitation turkey red) and naphthylamine claret during the last few years, but now there is little demand for this. Turkey red is too expensive for the American market, but the imitation has gone well.

At the Merrimack Company they have much trouble with their operatives, but manufacturers have combined, and are very stubborn. Mr. Gulline said if they were to yield once they would not have a minute's peace in future. By agreement they shut down all the mills immediately one mill's hands strike, and thus all Lowell is idle. The hands soon surrender and resume on the old conditions. There was a strike of engravers a few years ago, and the Merrimack, instead of submitting, sent all their rollers to England to be engraved. They thus lost $300,000, but they gained in the long run.

Referring to engraving, he said they were forced to keep a large number of rollers in stock, but yet they risked much. Copper is so dear that they often turn

rollers down and chance repeat orders. English firms having many more patterns, have to keep more rollers on stock in case of repeat orders. The firm, like other similar firms, does its own pattern cards, labelling, etc., but has outside selling agents. It seems they do almost everything —far too much according to some folks. At one time they used to have English and Irish operatives, but now mostly Greeks and Armenians.

The men are encouraged to work up to their utmost capacity. At one time if a man returned more than the usual amount of work the foreman used to stop the excess but this has been done away with and the men allowed to work their best. I asked why they ran their machines at such a high speed. He said they could not exist if they ran slower. It would not pay them, so they run (in the printing department) at top speed, from early morning until night, the operative being present the whole time, taking food now and again but having no definite meal time. My informant asked why we ran slower in England and hinted at the trade unions having something to do with it. How is it that, in America, the best operatives are English, and the machines used are similar to ours, yet they run theirs quicker? The American workmen run their machines at the greatest capacity and endeavour to get through as much work as possible, whereas the English workmen—well they don't. Webb, in his "Industrial Democracy," blames the unions and says they are engaged in a gigantic conspiracy to hinder and retard the development of labour saving appliances in this country. The action of their members in failing to exercise due diligence in working new machines is equivalent to absolute dishonesty. The men are too much in league in England, whereas in the United States, said Mr. Gulline, the slightest movement in unison is detected and, where possible, prevented. Some English unions enforce the employers to introduce new machinery, but this is exceptional, and in general they

belittle its saving and work it carelessly with the intention of showing that only so much work can be done in a certain time. Present-day conditions do not sanction such methods, and, as Sir R. Giffen says, there is enough indolence and routine mismanagement in English manufacture to make it desirable in every way to have the stimulus of foreign competition applied.

Yet it is difficult to strike a happy medium between the cause of labour and that of industrial development. Other countries are developing towards our position as regards the power of labour, and in the near future there will be a time when turning Lowell idle will no longer avail. But there is one thing that all in this country should be convinced of. If we are going to keep our position, the efficacy of new machinery must be recognised. The development and progress of our manufacturing industry during the last hundred years has been marvellous, surpassing by far the progress made in the previous history of the world, and the rapid advance of the United States of America in recent times has perhaps been still more phenomenal. These advances have been due in the main to the inventions on either side of the Atlantic. In countries where labour saving machinery has not developed, man has been uniformly found in his lowest and most humiliating state of degradation, and such would still have been his condition throughout the world without its introduction.

I found that at Lowell textile manufacturing companies are allowed a reduction in land rates to encourage industry.

Returning to the Merrimack, I noticed gas singeing was used, and bleaching carried on in the usual way. They have the system of having one floor for one operation, another for another, transferring the cloth through holes in the ceiling. This struck me as being very good, but I was told it meant a lot of trucking. I found this system also carried out in some German works, while at one

American bleachworks the trucking was facilitated by a series of small elevators.

The Hamilton works in Lowell, which I was fortunate to see, turns out prints, ticks, flannels, stripes, and shirtings; has 110,000 spindles and 3,000 looms. It has a capital of $1,800,000 and thus is among the biggest enterprises in Lowell.

Here they pad mordants and then dye in the strand dyeing machines. Indeed I found the jigger very seldom used in the United States. The printing machines ran very large amounts. Instead of printing such small lots as 30 pieces they would not run a machine for such an amount but rather for 300 pieces. There is the same setting up of the machine whether a large or small number of pieces be run off, and the saving of the large scale is shown. The men have breakfast at 6, before starting, and continue without any interval until 5-30 p.m. The owners think this the better plan, although they stop from 12 till 1 in the spinning and weaving departments; they cease work at 12 on Saturdays. The printer thought the American worker did not actually work as hard as the Englishman, and he was capable of judging since he had been for a long time with a well-known firm of printers near Manchester.

He said they had no difficulty with their hands. The foremen were often English but many of the lower hands were of other nationalities not so advanced industrially, such as Southern Europeans. The immigrants to these States contain more and more of Eastern and Southern Europeans and in the cotton mills we find Greeks, Poles, Armenians, and other nationalities, instead of the Western Europeans who used to be there. French people worked at spinning and weaving but not in the dyeing departments.

Here, and in other mills, they had automatic counters in the packing rooms. Girls sat at machines and recorded,

in typewriter fashion, lengths which were called out to them. The machine recorded the addition of these numbers and also gave other information regarding the same.

Lawrence, situated, like Lowell, on the Merrimack River, is engaged principally in the worsted and woollen industry; but some cotton is treated just as is the case in Yorkshire. The river has a fine fall, and thus provides energy for a grand line of mills arranged on both its banks. These mills are the largest in the world, and no place shows as great concentration as exists along the Merrimack at this point. Lawrence has a population of about 63,000, and over twenty mills engaged in textile manufacture. There is one specialised bleachery and one dyeworks dyeing woollen and worsted yarns. The surroundings and conditions did not appeal to me as much as the excellent conditions at Lowell.

The Pemberton is a large works which dyes the warps or raw cotton before weaving and spinning respectively. The superintendent said hank dyeing had gone out because it was too expensive. Warp dyeing is more rapid and requires less labour than hank dyeing. Here I saw them dyeing warps with logwood and with iron and soda (to give a buff). The machine used was of the ordinary type, the cloth passing over rollers through the solution and between a nip: the same machine was used for sulphur colours. They were dyeing with a sulphur indigo blue, which had a deceptive bronzy real indigo appearance. They used few colours but large quantities of each. They had a very crude raw stock dyeing machine, in which the cotton and dye solution were placed together in a tank and allowed to flow over into a long cistern. By a series of mechanical rakes the cotton was dragged along and finally between a pair of rollers. The rollers going rather quickly, sent the cotton off into a basket, from which it was taken and treated preparatory to spinning. The whole

arrangement, similar to that used in wool scouring, struck me as clumsy and unscientific.

The Klauder-Weldon raw stock dyeing machine was also in use. Here the raw cotton is placed in a perforated cylinder which revolves in another concentric cylinder containing the dye liquor. This was certainly a better machine than the other. They made various cotton cloths here, but principally denims and other coarse cloths.

The Pacific Mills and the Arlington (in another quarter of Lawrence) were visited. The laboratories of these two mills are thoroughly up-to-date, and directed by trained chemists. Mr. Alden, to whom I was referred at the Pacific Mill, had lectured on printing at the Massachusetts Institute of Technology. The Arlington Manufacturing Company has a capital of $1,000,000, and treats woollen, worsted and cotton yarns; while the Pacific, with a similar capital, prints cotton and worsted goods in great variety, and has 240,000 spindles and 6,800 looms.

Fall River, nicely situated near the mouth of the river of that name, is the principal cotton town of America, and contains a large portion of that country's spindles and looms. The river is named from its rapid fall, the power obtained from which is utilised in the mills. There is a population of over 100,000, and sixty mills are engaged in the textile industry. Of these two are specialised print-works; one a bleachworks, also finishing its goods; a dyeworks; and another doing dyeing and bleaching. Of the remainder, some dye and bleach for themselves, but Fall River probably is as specialised as any place in the States. The capital of the mills varies from $2,000,000, at the Fall River Ironworks (a textile manufacturing concern with a peculiar name), to as low as $20,000. Fall River had just passed through a strike when I arrived. Water is obtained in this district from lakes which occur here and there, and it is said to be very good. New England, like Lancashire, has a plentiful supply of pure

water which requires no treatment before use in the mills. Indeed Massachusetts is covered with small lakes, many of which are used for industrial purposes.

The Fall River Bleachery is situated on a lake from which it derives its water. It is devoted to bleaching and finishing cotton piece goods, has a capital of $600,000, and a daily output of 35 tons. Only low pressure tiers are in use, and the whole works is designed after ours. Gas or plate singeing is used according to the nature of the cloth, and, in one case, a thick cloth was being singed on both sides by means of an arrangement of four singeing cylinders. This cloth was afterwards to be coated with varnish for making insulating material. The works receives all classes of cloth, having machines of suitable kinds to deal with them. Blue dyestuffs were added during finishing, and in one case a mixture of saffranine and blue was used for the goods of a cheap collar maker.

The drying cylinders were of importance. The chemist thought that the best arrangement was to place first horizontally and then vertically, because, if all were vertical, the steam escaping from the wet cloth below would damp the cloth above; and if all horizontal, then too much space would be taken up. In order to save more space they had just introduced the "Cell Dryer," and as this matter of saving space is of more importance in congested England than across there no apology is needed for describing this efficient machine.

The machine known as the Cell Dryer consists of a big box containing a number (about fifty) of smaller copper boxes. These contain high pressure steam (about 15 lbs. per square inch), over which the cloth is sent by means of rollers, which in this case were worked by a small motor. One can dry much quicker by this means, for the machine I saw ran at a tremendous rate. With the big roller dryers you have a large area exposed, thus radiating the heat, whereas in this compact machine the heat is confined to a

small box. I was so pleased with the machine that I called on its manufacturers in Boston and learned that the invention arose from long experience at the Cocheco Works, Dover, New Hampshire. It had been on the market two years, but was only now coming into use. There was already one in use in England. They have various arrangements and in one case I saw them planning the fitting of a printing machine with these cells so that the cloth and the blanket could be dried simultaneously. The cells are so small that a great saving in space is made, and also they can be arranged in any out-of-the-way place. Like other American machines it is best adapted to their industry; that is, where the same kind of cloth is continually being treated. The friction during the passage is very great, so that on putting the finger to the cloth, passing off the cells, an electric spark is obtained. Perhaps this would not be very advantageous to some of our finishes. I cannot see that there is any disadvantage from running many small lots off on this machine, although perhaps to run a white after a red, a cleaning of the cells might be necessary.

At the Merrimack Co. they told me the cell dryer worked very well indeed and was replacing the cans rapidly. A small machine could do the work of an enormous can machine, and they thought in time they would be universally used; the idea was so simple that it was peculiar that nobody had thought of it before. It has this advantage that if anything goes wrong it is more difficult to get at than the cylinder machine but, as the firm have brought out a cloth to feed with the cloth which is being dried, then as the machine threads itself up again, this difficulty is got over. Dyers are unanimous as to its efficiency so that those who have had trouble with the can system can well afford to give this machine their consideration. The machine is also adapted for yarn drying.

The stentering machines at the Fall River Bleachery

were enclosed. This certainly confines the heat, keeping the temperature to 120°F., and shields the operatives, but yet the steam from the cloth has no chance of escaping. Swissing, chasing, and other finishes were produced here. Englishmen on the premises said they ran their machines much faster than we run ours.

At the Barnaby Works, Fall River, weaving, dyeing, bleaching, and finishing are done, fine coloured cotton goods and yarns as well as silk novelties being turned out. Bleaching and dyeing are performed in all cases before weaving, and the dyer said warp dyeing was the thing of the hour, while hank dyeing, being too expensive, had gone out. In many works I heard of a tendency towards more warp dyeing, but there is still a fair amount of hank dyeing done, the Klauder-Welldon machine being principally used. Warp dyeing with indigo was done on the usual dip principle, and pumping was used to circulate during bleaching. I followed the goods from the dye-shed and saw them being quilled and beamed. After weaving the cloth is calendered and finished by various means.

There was little of interest here, the dye-house being superintended by an old man who had antiquated ideas. It was badly arranged, badly ventilated, dirty and old-fashioned. They only dyed for their own weaving sheds, which were adjacent to the dye-house.

At the Salts Manufacturing Company at Bridgport Conn., I found the Klauder-Welldon machines of principal interest.

This machine is found almost everywhere in the States, and everybody praises its efficiency. It consists of a vessel containing the dye liquor in which a drum revolves. On the outer rim, and at the centre of the drum, are sticks, between which the hanks are placed so that they are radially situated to the drum. In the movement of the drum, when passing certain points on the case of the

machine, the sticks on which the hanks are placed catch a metal strip and thus the hanks move round. In this way evenness of dyeing is produced, for all parts of the hanks come to similar positions consecutively. The machine is covered in so that for a part of the time, when the hanks come out of the liquor, they move in an atmosphere of steam, and in this way no great alteration in temperature is experienced. There is very little friction of the hanks, and the danger of tangling and hindering the weaving is very small. The liquor is used cold at first and then gradually heated up, the drum revolving slowly. For dyeing to shade with this machine, we act just as in the case of dyeing hanks by hand. There is an arrangement for lifting the whole drum out of the dye liquor and testing a little of the dyed goods. This dyeing to shade is of course difficult at first, but the whole of the operations with this machine, formidable at first, are quite simple after a time. Mr. Crabtree, the dyer, praised it highly, and, having been long accustomed to dyeing, could speak of the great saving of labour. The machine never goes wrong, and lasts until the metal wears away. It requires very little looking after, and once started can be left until the dyeing is finished. Mr. Crabtree said there was a natural antipathy to the introduction of new machinery, and often because of difficulties the trial stage is not prolonged far enough. He thought that this was often the case with this machine, but when the difficulties were once mastered the results were splendid. The Klauder-Weldon machine is, of course, only suitable for large lots, small quantities being done on the sticks, and therefore, one can understand that this machine is peculiarly suitable for American large scale operations. The machines are built for batches from 100 to 400 lbs., and there can be no doubt that for large quantities this is an extremely economical method of dyeing. I saw the machine at work dyeing developed blacks. With this machine every colour

cannot be used. For instance, it is difficult to dye basic colours, since uneven shades result. Again, the machine is difficult to clean, so that a change from one colour to another is troublesome. Its economical use depends on large lots to be dyed one shade, and in such a case it can be highly recommended. Many machines were made with copper linings, and this prevented the use of sulphur colours, but now they are made suitable for dyeing sulphur colours. Iron walls are used, and the machine is filled almost to the top with liquor. The pumping of the liquor is troublesome, but yet the machines work quite well.

At the Salts Company they have also a large warp dyeing machine on which they were developing blacks. They use a five-colour printing machine. In the spinning and weaving sheds they have a fine spray of water at the ceiling for keeping the atmosphere damp. There is a small laboratory attached to the dyeing department, but it did not appear very elaborate. The chemist, who worked there, had been at Yale University and also, as a volunteer, with one of the German colour firms. Mr. Crabtree was very much imbued with the spirit of technical education. "Nothing can be done without it, and England must wake up."

CHAPTER VIII.

CONDITIONS OF LIFE IN THE INDUSTRY.

Injurious conditions in dyeing—Remedies—England, Germany and America compared—The power of the workmen in Germany—The development in America—Wages in the three countries—America's high wages—Short hours—The German workman and the American.

Like most other industries that of dyeing is fraught with many evils. Among them may be mentioned the fine particles which get into the air during the polishing of yarn and when yarn dyed with chrome yellow and other colours is shaken; the poisonous effect of aniline vapour; the injury caused by the action of "chrome" on the skin; and the injurious vapour evolved during Prussian-blue dyeing, when men have been known to fall overcome by exposure to the fumes. Yet it cannot be said that occasional exposure to chemical vapours causes permanent injury because, as a matter of fact, chemists are usually healthy, despite the fact that they are exposed to fumes of various kinds. Statistics show indeed that the dyer is not by any means badly treated, for the death-rate of his trade is very little above the average for all trades.

Then Parliament protects the people well. The British factory regulations are the most stringent of all, and only last year (1905) the Home Office issued special regulations to employers using aniline and chrome. For aniline-black dyeing the precaution of good ventilation was enforced to prevent inhalation by the workmen, and in the case of

chrome, india-rubber gloves were ordered to ensure against attacks made by that chemical upon the skin and knuckles.

High wages compensates for many of these evils in America, but to enforce our restrictions seems a safer policy, since "whitewash or machinery fences cannot be spent in drink or wasted in betting."

Cleanliness is of great importance in the industry under consideration. Many pieces are spoiled by dirty conditions, splashing of dye-liquor, etc. A large Manchester firm of engineers have their machines painted white and the walls white-washed continually. They say it pays them because a better feeling is induced in their workpeople. Much has been said against modern works having inside walls of white tiles, but the initial expense is justified when all the advantages are considered. Some works in America employ youths to go round the works, scrubbing and dusting, for the small amount of money spent in wages is said to be more than earned by the refreshing effect of the improved conditions under which the people work.

It must be said that in the large works there is a movement towards bettering things, and that these modern creations more than bear comparison with the conditions they have displaced. Thus in some parts of Germany we have dyeing operations carried on in the most wretched holes, whereas in other parts the conditions are much better. At Chemnitz and Elberfeld the dye-works are arranged along the respective rivers, and a trip along these is a revelation. At the former place there are works made from what used to be houses. The offices and dyeing departments are in the house, whereas the backyard is usually covered in and used as the dyeing department. The latter section is very dirty and full of steam: dye-baths crowd upon bleaching apparatus and hank mercerisers, and the small space presents nothing but a mass of disorder.

On the other hand, at Barmen and Mülhausen, I paid

visits to establishments presenting entirely different conditions. At one of these, the absence of steam was noticeable: it was driven through the roof by a current of cold air coming through goods in the floor. The works were well ventilated, had plenty of space and light, and none of the conditions seemed injurious. I think in the particulars above given the subsidiary dye industry has developed in the same way as the primary textile industries. "The safety, the cleanliness, the ventilation in all the factories, show that agitation and legislation, supported by the humanity of employers, as well as the self-interest of workmen, have raised the sanitary conditions to a higher level in the factories than in the homes of even our modern workmen." The above has been said of the cotton industry but still even in this industry we have survivals of the old conditions, and similarly, in the dyeing branch, the first examples given may be taken as corresponding odious survivals.

In many of the American mills I found the air very bad, there being little provision for ventilation. In some cases they seemed to consider the dye-house as a mere shed, the escaping steam being left to itself to find an outlet. The machines were crowded together, surrounded by puddles of water and neglected. Of course this was in the older parts, but in the newer districts there are decided advances. The crude old conditions always survive where there are long-established concerns, so England might be expected to have most instances of these drawbacks. The more modern concerns in America are distinguished by well-built mills and clean places for the goods and operatives to move in. I have heard it stated that the conditions in the United States are worse than those in Lancashire. This is questionable and comparisons are difficult. Englishmen going there in the summer find the conditions disagreeable because the intense heat accentuates the defects. The fact that America has, in some cases,

such good conditions of life is a bad thing for this country, because the former is attracting some of the very best and most ambitious of our artizans, who are using their skill to compete with us. Obviously if the wealth producers go, our wealth must decrease.

As before stated, to draw a comparison between the three countries in the matter of industrial conditions is difficult. All possess bad and good, but I feel assured that on the whole Germany possesses the very worst conditions existing in the industry, although at the same time the environment in some of her works cannot be beaten anywhere. England and New England also have some bad conditions, and there is little to choose between the two, as our young friend is apparently following in our footsteps as regards the industry and legislation affecting it. All the countries are learning that their wealth is to be found in the quality of their citizens, and that improving industrial conditions is the most rational form of patriotism.

As regards industrial organisation it is well known that the unions in Germany and in America are not so strong as those in England, but yet they are growing at a rate which is alarming to many people.

In Germany trade unionism is being swamped by larger social movements, the German workman giving himself up to political effort and caring little for carrying on strikes. Their Socialistic crusade is very strong, but trade unionism after the English system is emerging.* The people are, as is usual in Germany, under the thumb of the police, who have the right to close meetings and interfere in other ways. Strikes are not of frequent occurrence. The masters are so strong that the workmen perceive the futility of standing out. Yet strikes do occur, and in January 1906,

* It may be said that since the last General Election the English labour movement is following the German method, that is, becoming more a political movement.

I heard of a case at the Works of the Badische Anilin and Soda Fabric at Ludwigshafen (about the largest colour works in Germany). The struggle lasted a few days and ended in the men winning and being awarded many thousand marks a year more in wages. Such cases are rare.

While in Germany I read the following telegram from a Berlin correspondent to an English daily. "All the looms of the Saxony-Thuringia Employers' Union have ceased working, and workpeople have been locked out to the number of 40,000. In addition to this the dyeing and finishing works have closed, affecting 25,000 hands. The lock-out is to last until the end of the year unless the workpeople agree to accept the masters' conditions." I hurried to this district and on to Chemnitz, intending to hear and see something of such a strike, but I was doomed to disappointment. The only strike I could hear of in this district was that of a few book-binders. It was evident that the disturbance existed in the press only, and was only one instance of the way in which we are given erroneous ideas of the state of affairs in Germany.

Although trade unionism proper does not flourish in Germany, the workmen have other ways of promoting their interests. Co-operation between employers and employed has been brought about, resulting in the establishment of insurance against accident and sickness, besides creating a vast system of old-age pensions. In this way much of the best work of our unions and friendly societies is being carried on.

In the United States agitation is more in the way of spasmodic outbursts than of a continuous and organized effort on the part of the workpeople to assert their rights. The mixture of races militates against the union of labour, and workmen are generally ready to make individual bargains with individual employers. There was a strike at Passaic, New Jersey, when I was there, but instead of there being a stubborn, sensible resistance, the struggle lasted

merely one day, and was distinguished by its intensity. The rioters paraded the streets and attempted to prevent others from resuming work. This resulted in disorder, which prevailed long enough for all the police and many civilians in the town to receive injury before the firemen restored order with hose-pipes. In this case the rioters were Italians. But the people are seeing the folly of such outbreaks, and the English and Irish are introducing their more systematic methods in opposition to the fruitless riot. They are bringing about a state of affairs similar to our own, and provide the ring-leaders in the workmen's organisations. The employers have strong combinations against them as previously mentioned in Chapter VII., and take all opportunities of engaging French Canadians or other non-union labour.

A comparison of wages is an extremely difficult matter, and the study of mere figures avails very little. The purchasing power of the wage has always to be considered along with the wage received, and when we consider the variable prices of commodities which are purchased, the difficulties of comparison are apparent.

English people living in Germany thought German wages lower than English, that is comparable to the cost of living. American wages were acknowledged the highest, both actually and relatively to the price of commodities. Calico printers, in the two countries visited, gave me the figures of £2. 5s. for Germany, £3 for England, and £6 for America, as the wages of first-class calico printers in the three countries mentioned. At Lowell, Mass., I came across a calico printer who had worked in Scotland and in the Manchester district, and was therefore well suited for my purpose of comparison. He said that conditions were immeasurably better in the United States than in the Old Country, although one had always a desire to see one's birthplace and to return home when life's work might be finished. He found the cost of living very little different

from that in England, prices varying in different districts, but articles of food being about the same as "at home," milk being often cheaper. Clothes he found dearer, as were house rents, amusements and general luxuries. For a quiet life, however, the cost is similar to that of living in England. If a man is ambitious he said the United States is the place of opportunities and would push him on, but without ambition the man might as well stay at home.

But simply to compare workman and workman in rate of wages is of little use unless we know how much employment is furnished at that rate.

There is an upward tendency of wages in Germany, and this brings satisfaction. It is said that one does not find the extremes of remuneration in that country as one finds in England, the German wages being more evenly balanced. That may be so, but are not the extremes the results of business development? There are still bigger extremes across the Atlantic.

America is teaching the world the economy of high wages, and this factor in her production is, I think, ensuring the best possible future. From time to time we hear that some European countries are beating us in some special line of industry because they have lower wages. For instance a distinguished Manchester chemist said a short time ago that Germany's low wages and longer hours were driving us out of many markets. I have no intention of giving a full discussion of this subject (space does not allow that), but a few facts concerning this matter cannot be considered out of place. Labour is physical and muscular exertion, and always will remain so no matter how intellectually guided. If the actual force be not replaced the frame works itself out and labour becomes economically of less and less value. The first hours of labour have been proved the most efficient. Those engaged in industry in this country know that little work is done before breakfast time, and probably the cost of running

the works during this time is higher than the returns for that period.

The shortening of the working-day has been introduced with good results into some of the industries (particularly engineering) of this country; Germany is following at a distance and in some parts of America the people are awakening to the fact that short hours are the most economical.

Some of the large German concerns (for example the colour concerns) are introducing the eight hours' day and allowing a half-day on Saturday. It is said that the United States have the eight hours' day in many industries. I did not find this the case in the textile and dyeing industries.

As has been previously mentioned, remuneration is higher in America than elsewhere, and that in Germany the reward of labour is lower than it is in England. The low condition of wages is keeping the German back so that the labourer is many decades behind the Englishman. It is true that he is forced into the rudiments of education, but class distinctions are so rigid in Germany that he finds it difficult to rise to higher spheres. His wages are so low that his movements are restricted to narrow limits. In England one finds hundreds of "self-made men" who now occupy the highest of positions. This class of man is practically unknown in Germany, but on the other hand still better known in America than in England. The opportunities presented to children of poor parents in the United States and England made it possible for a child to forge ahead, and in this way the growth of a pure labouring class is impossible.

Germany is regarded as the home of Education, but I think that it is only one part of education, namely University Education which really flourishes in Germany. One cannot enter the Universities without means, and thus the larger part of the people is barred from participating in

the " splendid educational facilities " of the country. One becomes tired of hearing of *other* countries' superior educational facilities, and I think opinions of that kind are fallacious. However, returning to the subject. Low wages is a large determinant in a man's welfare, as a man living from hand to mouth has small chance of departing from the groove into which he was born.

In the United States, if an employer wishes to economise labour he does not begin by discharging those receiving high salaries, as is often the case in this country, but he generally achieves his purpose at the expense of the lowest paid hands, and thus the influx of unskilled labour does not affect the higher salaries. A man is given any salary, no matter how big, but just so far as he can economise production. Some of the managers of mills in New England are receiving very high remuneration.

CHAPTER IX.

EFFICIENCY IN THE INDUSTRY.

Dyeing in Germany—Application of science to the art—The position in America—English workmen in America—Empiricism and science—Arrangement of the works—Using up of wastes—Aids to manufacture—Specialisation in the industry—Dyeworks and machine shops—High specialisation in England—British pessimism.

TAKING a general view I must say that the German dyeing industry is a few years behind ours in many respects. It is certainly highly developed in some branches but in general development we lead. As previously stated at Chemnitz and other parts we find houses with the back yards containing dyeing plant, and it comes as a surprise to see that a certain house has a sign up indicating that within silk is dyed or cotton yarn bleached. Nor are such places few in number. Yet there is a tendency towards the extinction of such holes and large and better works are arising on all hands. But it cannot be said that their largest works are as large as the huge establishments which Lancashire and Yorkshire can boast of. The size of the factory is gradually growing in Germany and the number of businesses is decreasing. Thus from 1880 to 1890 the number of sheds weaving cotton decreased from 56,000 to 32,000, whereas the output increased enormously. The dyeing industry shows a similar tendency.

As to the state of the industry in Germany, reports in German industrial centres tell us that the prices of dye stuffs are falling considerably, as are also, in most districts,

the prices paid for dyeing. At Chemnitz the prices paid for dyeing silk, wool, cotton and linen showed a steady decline in 1905, and for the same period the business of dyeing both silk and cotton was not by any means good in Crefeld. This was the case for both black and colour dyeing. Turkey red is becoming less and less in demand everywhere, cheaper substitutes being eagerly sought.

We hear much about the application of chemistry to art in Germany, but I did not find that the Germans employ more scientific skill in their dyeing industry. The wages paid in dyeing are too small to command the best skill and this drifts to the colour works which employ many chemists in all departments.

In dyeing, as with all scientific arts, countries approach more and more to the same state of efficiency. Secrets in dyeing and scouring existed more in the past and if a country is much ahead (as we previously were) then through the excellent periodicals which go all over the world and through the partial mobility of labour between countries equality tends to result. This process of diffusion is, of course, slow, and the countries gain certain advantages during the diffusion, but what would result if this fictitious state of equality were arrived at? New inventions would arise, which would be known and patented all over the world, and success would lie in the judicious use of such inventions. England has the advantage of climate, hereditary skill and other things, but that of being modern and utilising modern invention is perhaps more efficacious.

In the industry I studied, I could find little of the marvellous methods of the Americans. I think nearly all their success in dyeing can be accounted for by the largeness of the demand. It seemed to me that they were following us at a distance and, by capturing as much of our talent as possible, trying to make that distance as small as possible.

One gets tired of hearing the American workmen praised.

Who is he? We find a collection of nationalities among whom the British immigrant is admittedly the best and certainly receives the highest wages. Evidence before the Industrial Commission of the United States, 1900, showed that England was practically supplying the demand for expert trained workmen in the United States. The Englishmen I met engaged in the American textile industry said that the American workman did not work really as hard as the Englishman although, owing to the different conditions, more was turned out by him. Englishmen are found everywhere in the textile industry and the dyeing branch of that industry has its share of English labour. Many Germans are employed in the calico printing works but the responsible positions are often filled by Englishmen. I got quite used to hearing managers, to whom I was introduced, declare they were from Manchester, and used to be with Lancashire firms. Emigration seems to be taking some of our best talent, perhaps to be used against us in foreign markets.

English machinery has been used largely, but more and more American is being introduced, machine shops springing up in all parts. Also Englishmen have been brought over to teach in the textile schools.

America is exceedingly rich in raw materials. She has splendid supplies of coal; water power; iron ores of great purity near the surface and close to coal and limestone; great stores of copper, lead, zinc, corundum, quicksilver, asbestos, asphaltum, nickel, cobalt, and kaoline; native wood of great variety and excellently adapted to manufacture; building stones, slate and marble, besides cotton and wool. These resources should always be considered in accounting for America's position in any industry. The differential advantage produced by these is often accounted for in other ways and among these the quality of the labour is given as a cause. This is hardly the case.

As previously stated the dyeing industry in America has not attained to our excellence, though they are quickly adopting our methods. When they get to our highly developed rule of thumb position they will possibly introduce scientific skill at a greater rate and then we must look out for squalls, if we have not in the meantime gone far ahead in that respect also. They have a few good textile schools, and the students are obtaining admission into industry.

Empirical methods are as prevalent in America as they are here. At one American works a man with no scientific training was seen giving directions to the dyers and dispensing colour in a most crude manner. The workmen came with their pots and received colour by means of a spoon from one or more of a dozen cans. By long experience the man could tell how much he took on the spoon, but he admitted that weighing was the better method. It was, however, too slow for them, as they could find a ready market when they used the other crude method. This gives some idea of what American dyeing is like. Would such empirical methods pay here? The workmen oscillated between this man and their jiggers bringing patterns and colour-pots until the right shade was obtained. Dyestuff was almost invariably introduced into the bath in pinches; either the importance of perfect solution was not recognised or the time taken in such operation was held of more consequence.

Yet I found some of the dye-works in America conducted on scientific lines. At the Arnold Print Works, North Adams, Mass, success is largely attributed to the systematic and scientific working of the mill, while the Merrimack and the Arlington mills, two of the foremost works in Massachusetts, are thoroughly up-to-date. The Arlington, of Lawrence, has a very fine laboratory, the chemist having an assistant from the neighbouring Lowell Textile School. They test nearly everything they receive, and do washing

and other tests for the dye-stuffs. The laboratory is neatly arranged and they have a Bradford machine for determinating the moisture in cotton. At the Merrimack they test all goods coming into the mill no matter where from. I pointed out that that was not necessary with the products of many of the large German concerns but the manager said the events of the past week had proved the wisdom of their plan. All the years they had received dye-stuffs from one of the largest German aniline colour firms, they had found no error until last week when the Rhodamine was returned as decidedly under strength. If they had used this, thousands of pieces would have been spoiled whereas the saving on this one case sufficiently paid them for all their expenditure on testing in the past.

The *organisation and arrangement of works* is of interest. Our works tend to one storey buildings, all the principal operations being conducted on the ground floor, and this I found to be also the case in many parts of Germany. The huge establishment of Bemberg at Barmen has four storeys and all the operations are carried on with plenty of room and systematic arrangement. Also heating is facilitated. The strand dyeing machines, the calenders, mercerising plant, and a few heavy machines we have on the ground floor, but upstairs we have jiggers, aniline black dyeing, etc. It struck me that skill had been used in designing the different departments, and the saving in the ground area covered seemed to warrant this foresight. The dyeing departments in the United States were seldom found of this nature. A bleach works would conduct all the wet operations on the ground floor and dry and fold above, while most of the dyeing was done on the ground: but some large works were neatly arranged in stories. Sometimes one storey would be set apart for one operation, another for another, until at the top the making up was arrived at. A system of elevators facilitated the operation in this case. But I was told this method necessitated

a large amount of trucking, and although ground rent was saved, yet it was doubtful if any actual saving resulted. In many works in America the machines and their arrangement were the principal things to interest a visitor. At the Gera Mills, Passaic, New Jersey they have a double line of strand dyeing machines all driven from the same shaft, using the same steam pipe and having the same exhaust channel in the middle of the house. In many dye houses we find the machines arranged down both sides leaving the centre free and having separate shafts and pipes. Thus we have a bigger outlay in fittings than at the Gera Mills.

At the present time one of the principal roads to success lies in *using up wastes*. Lord Masham said he maintained his house out of his sewer and so many things are now recovered which formerly went into the sewers that manufacture has assumed quite a different aspect. This is undoubtedly the department where science can make itself felt and where, in fact, it is certainly being effective. At M. Gladbach I saw cotton waste which had been imported from Darwen being used in making very fine cotton blankets. English machinery is used in the manufacture, and the blankets are seen on nearly all beds in Germany. It is true that cotton does not grow on the back of an animal and has not the value of wool as a clothing material, but yet the Germans having learned the art of cheap imitation to please the eye, other considerations are easily outweighed. The 'raised' flannelettes from this district are really fine. Owing to the large demand, the industry has greatly developed, so that they can produce goods of beautiful designs much cheaper than we can. In America the treatment of wastes has received little consideration, and wastefulness is an element of weakness in their manufacture. Owing to their huge resources the genius for petty economies has not been developed. The artizan is habitually indifferent to economy of material, and finds efforts to economise labour more to the point. On the other

hand, in Germany, where conditions are different, the success of many of the business concerns is due to attention to detail and the practising of small economies.

In touring Germany and America one cannot help noticeing how industry receives all manner of assistance from the community. English people abhor factory chimneys whereas our rivals welcome them for the prosperity which they indicate. We are becoming famous for the asserting of our rights. This trait in our characters has increased our railway expenses so that the ensuing high cost of transport has shut us out of many markets; but in Germany the State railways assist industry in all possible ways and in the United States they even allow express trains to run down the main streets rather than increase the expenses of the railways—their benefactors. All the mills have their railway sidings (a characteristic feature showing how railways are developing the United States) and the people recognise that any impediment they place in the way of this development is only a hindrance to their own progression. Both in Germany and in the United States one finds the railway apparently playing a more important part in industry than here. It is a usual thing to see lurries bringing goods into Manchester from outlying districts. Such a thing is not seen in Germany or America. Of course they have not the fine roads we have, but would prefer building a railway to a road. America seems to proclaim that railway development and general industrial development are synonymous, and Germany fully endorses this. Thus coal is found in Massachusetts, but, being mixed with earth, it is of little value. As a consequence all the coal for the factories, in that important State, comes by rail. Hence one can understand what that part of the country owes to railways.

One hears little in the United States about the development of waterways. The much talked of Erie Canal, so much used in the past for developing New York State,

is now only used for lumber, salt and coal, and most of the large business enterprises use the railway only for transport. Similarly in Germany canals are principally used for connecting the big rivers. They have the mighty Rhine and other rivers but these are quite different factors from canals.

In connection with the aid afforded to manufacture in America, it must be mentioned that a manufacturer is not summoned immediately black smoke appears from his chimney top. I saw black smoke and even nitric acid fumes issuing from chimneys at Passaic and the authorities seemed to allow manufacture to proceed practically unrestrained. As mentioned in another part grants of land are made at reduced rates to manufacturers in Lowell and other cities in America.

Referring to *Specialisation in the industry* I have said that there is a lack of specialisation in Germany because their textile industry (and consequently their dyeing industry) is not so large as ours. Whole works do not devote themselves to one special kind of dyeing (except that one comes across small works devoted to artificial silk dyeing) and usually a dye works undertakes a variety of operations. Thus at one of the largest works in Mülhausen they were mercerising, padding, printing, soaping and calendering cotton besides bleaching and dyeing woollens. In America, as stated in another part, we find spinning, weaving and dyeing taking place under one roof, but in Germany, as the textile industry arose, at the same time the subsidiary industries found birth, and separate dyeing establishments resulted. But this separate existence of industry is not found in all cases for all the large textile machine shops are attached to dye works which, using the machines, also place them on the market.

Haubold of Chemnitz, Gebauer of Berlin, Kleinewefer of Crefeld, and Bemberg of Barmen, the largest textile machine shops, originated long ago as dye works. In the

course of time, machines were invented in their works to facilitate the dyeing and naturally they placed them on the market. This led to the purchase of adjacent machine works and to the formation of engineering departments, which in many cases have been more profitable than the original business. Those working the machines have been best able to point out improvements, and thus objects of great utility have resulted: not only have the works made their own patent machines but they have turned to the construction of machinery of all kinds.

The firm of Bemberg of Barmen was originally a dye and finishing works for piece goods, but it absorbed the small engineering works of Mommer, and is now developing that along with the dyeing branch. They make a hank merceriser, calenders, Brahma presses, etc., and used to make a cop dyer until competition became too keen.

Gebauer's of Berlin was originally a dye works but seeing the importance of machines and knowing the requirements of the trade the firm began long ago to make machinery. They have since bought a works for making woollen machinery. They export machines to all parts, but few to England.

Kleinewefer's in Crefeld have a large mercerising plant and a dyeing and bleaching department alongside a machine shop where they make silk finishing machinery, etc.

Haubold's of Chemnitz is about the largest textile machine works in Germany and they run a dye works under the same direction.

Also in America I saw an engineering department attached to a mill at Lowell, the German example being followed in this case. The Cocheco Manufacturing Co., at Dover, New Hampshire, make the cell dryer and have put it on the market, but their principal business is the making of all kinds of cotton goods, velvets and velveteens, dyeing, bleaching and printing.

Thus we have examples in Germany and in America

where the engineering and the dyeing industries are carried on under the one direction. Engineering of this kind is done in England at special branches of engineering works and to these works different inventions are taken. We have specialisation in developed industries as spinning and weaving are separate, and not dyeing and engineering carried on together.

Again dyeing is found attached to the spinning and weaving sheds in America, and even great developments in the manufacture of cloth have not resulted in dyeing breaking away as a separate branch of industry. The tendency there is rather for the concerns to get larger in the way of self-sustenance than by splitting up. The Gera Mills at Passaic, New Jersey, weave woollens and have started to spin their own yarns in order to ensure a good supply. Expansion is seldom in the way of specialisation. The dyeing industry is more specialised in England than anywhere and the staple industries of Lancashire and Yorkshire provide the highest examples. Whether specialised production would be the best at the present time for the rapidly changing textile industries of New England cannot be said but certain it is that for us it has brought the greatest economy so that the world is enviously striving after our state. We have specialisation so developed that one district spins and another weaves (for example, Bolton and Blackburn) while in dyeing one firm is specially noted for its turkey reds, another for its blacks, and so on. These have been developed so far that they can defeat all comers the world over whereas, without this specialisation, success in our varied foreign markets would not be so great. It leads to special training in particular branches and this mode of organisation is absolutely essential to British success. Similarly, in the worsted industry, we have the wool merchant, comber, spinner, weaver, piece merchant, dyer and distributer, these operations being often carried on separately, while

on the other hand I went through mills in the United States, carding, spinning, weaving, dyeing, and finishing their woollens. We have even specialisation in the separate branches; manufacturers confining themselves to particular kinds of cloth. The dyeing is given out by the merchants, whereas in the United States it is done almost invariably on the premises. In specialisation lies the strength of the industries, because a man concentrating his energies on one particular kind of work, does it as economically and as perfectly as possible. The bleachers do their share of the work and supply the goods to the dyer and printer cheaper than the manufacturers could do them themselves. Specialisation of labour cheapens production because a habit is slowly formed and we learn the shortest and best way of doing a thing only gradually. However, it is not my intention to discuss in full this well-known economic question, but only to treat of its bearing on the industry I have investigated.

America has not the variety in her dyeing, and such large lots are dyed at once that the processes become almost purely mechanical. Perhaps that is the reason why the dye works are attached to weaving sheds more than they are in this country. Or is it that the industry is not so good as ours, and the state of the development is good enough to suit the market? In this case specialised training in dyeing is not so much needed as it is here.

We can safely say that as far as the dyeing industry is concerned, the exhortations sometimes addressed to us to reform our methods do not urgently call for consideration. Mr. Hooper, Secretary of the Bradford Chamber of Commerce, lecturing at the Birmingham University, denied that the Yorkshire industries needed such rebuke. "The very existence of the Yorkshire manufacturers and merchants depends upon them keeping abreast with the times. No industry in the world has been subjected to so many changes or suffered so much

from the vagaries of fashion as has the worsted industry, no other industry has shown more readiness to throw out obsolete machinery and install new plant in order to meet the ever changing requirements of the day; and so long as the Yorkshire manufacturers, dyers, and merchants maintain their present enterprise, inventiveness, and vigour, they have nothing to fear from foreign competition." Similarly Lancashire can hope for the same emergence for she still possesses the qualities which the late Elijah Helm emphasised before the same University—an energetic self-reliant and inventive people, and an excellent industrial and commercial organisation. "The natural life seems as vigorous as ever, but the utmost energy and resource must be applied in every direction if we are to hold our own." (Sir R. Giffen).

CHAPTER X.

COLOUR PRODUCTION

The German works—Past, Present, and Future—Combination and its possible effects—Our position—Possible remedies—Protection—Patent legislation—Organisation of the industry in Germany.

The German colour establishments are at once the most perfectly developed and scientifically managed organisations of the world and pay dividends up to 35 per cent.

We, in England, are apt to give so much attention to our staple industries as to forget the importance of the industries which, although subsidising, are almost as important as the primary ones. The coal tar colour industry has received much attention but only historically in order to elucidate our past faults and conservatism. The past has been reviewed whereas a peep into the future would be more beneficial. Everybody knows the story of how Germany has beaten us in the march of science and deprived us of our aniline dye industry; how we send coal tar to her and receive back finished products for which we pay dearly; and how that, now her works are so large, competition is difficult. But the possibilities of development have not been argued.

With the discovery of artificial colouring matters the industry arose in England and in France as the outcome of a series of chemical triumphs. Hofmann was in England experimenting, but the Germans were not behind hand, and soon their fellow countryman, mentioned above,

joined them. It is said that it would have paid England to have given this chemist a million of money to stop. England was better prepared to develop the industry because of her cheap acid, alkali, fuel, intermediate products, and raw materials, and also her gas industry was more developed than that of any other country. Then, thanks to Liebig, who led the way, an army of young chemists developed the industry in Germany, relying on foreign raw materials. Later the acid and alkali industries developed in consequence of this impetus and had to thank artificial colours for the change. The coal tar industry developed slower than that of dye-stuffs and, consequently, Germany still relies on foreign raw materials (the quantity of these is becoming less and less).

The success of their colour industry is attributed by Germans to their research chemists, but the true success lies really in the encouragement afforded these men. At first the German chemists came to England for capital to work out their ideas, and many were engaged in the Manchester district. But afterwards they found they could get money at home where such men as Bayer and Cassella, who were not chemists, supplied the business and financial element. Brilliant chemists left England to achieve great success in the German research laboratories. Professor O. N. Witt says progress in Germany is due to the development of the people during the last hundred years, to research, to the combination and technique, and to the fortunate organisation of chemical industry. Their Chemical Society has had a big influence and, along with the sister Industrial Chemical Society, has fostered the industry through its journal.

That is the past; and the fact that these concerns produce about £50,000,000 of coal tar colours annually gives some idea of the present.

In considering the loss of an industry, we must not consider it a pure loss, but must remember that the people

turn to something else which might be more profitable. The actual loss is the difference in income obtained in the two cases by the employment of the same labour and capital in different directions. Certain countries are particularly adapted for working certain industries and the arrangement of industries between countries changes with time. Thus the English cotton industry came from the Netherlands, and now cotton mills exist nearly all over the world. Yet when we consider the loss of our coal tar industry we cannot put ourselves off by saying that possibly the balance is on our side, possibly the labour and capital are now more economically directed. What are the facts of the case? We have all the raw materials here at home, we have need of the dye-stuffs produced abroad, and thirdly the returns of the German firms tell us that their industry is a most profitable one. In short, considering some of our best chemists are employed with these firms, we could really do with the German coal tar industry.

The existence of this huge industry in Germany has also another effect. A short time ago a German professor deplored that Germany was getting behind in the analytical and inorganic branches of chemistry. He said Paris and England were taking the lead. The fact is that the colour works in Germany are absorbing so many of the German chemical students that as a consequence the organic side of chemistry is flourishing. In this instance we have the demand for labour influencing the direction of study. These large works have been very influential in maintaining the standard of teaching of industrial chemistry in Germany. Further, it is my firm belief that if the German colour works suddenly vanished we should hear little more of the scientific German who is busy applying science to industry. The industry is a great asset to Germany.

Turning to the industry itself we find in process of manufacture things which were unknown a few years or

even a few months ago. With intellectual advancement man's tastes become more and more complex and in his taste for new colours lies the success of the industry under review. Like all other innovations artificial colours have not been received enthusiastically. Albumen printing did not prove efficient at first, and there was a crusade against the use of aniline colours. Printing according to the old methods began to thrive and it took time for the people to see their folly, perfect the new method, and find it revolutionary. Since then the progress has been by leaps and bounds, until now-a-days we are threatened with a new development.

The separate firms have become very large, the firms of Friedrich Bayer, the Berlin Actien Gesellschaft für Anilinfabrikation, and the Badische Anilin und Soda Fabrik being on the road to complete union. The Bayer and the Badische firms are already united in the United States. Also the two Frankfort firms of Leopold Cassella of Mainkur and Meister Lucius and Brüning of Höchst are acting similarly, so that two large concerns promise to arise and drive small competitors out of the market. The small firms are a menace to the larger ones, and from time to time struggles take place. An example came to my notice of a Swiss and a German firm selling the same product and the latter firm wishing to come to some agreement as to price in order to avoid ruinous competition. It was sought to arrange as to the sharing of the profits, but, on the smaller firm holding out, war began. The larger organisation will probably win and perhaps injure the smaller one, so that in this way the powerful combination mentioned may get the market to themselves. Further, it is known that there are certain arrangements between different firms of the two unions mentioned. There is an agreement between two such firms to keep up the price of sulphur blacks in M. Gladbach and the indigo convention between the Badische and Höchst con-

cerns is well known. Numerous other conventions exist in the colour industry such as that between the British Alizarin Company and the foreign producers of that substance. Competition forces the price of colours down enormously and agreements like the above are welcome retreats for both parties. But if such overtures can take place between units of rival organisations, can we not conceive of a time when one firm only will exist in Germany, or at any rate such a connection between the two as to create a monopoly? Such a powerful combination could afford to undersell our small works, drive them from existence, and finally get the dyeing industry of this country in its grasp. They might put the price up in America and at home, and while keeping the English price very low, yet obtain their profit—supply price may be put below cost of production in order to gain a market. The price of a colour is so uncertain that this could easily be done if rigid combination were brought about in Germany. A German firm which exploited the direct cotton colours started selling one of these products at 6s. a lb., whereas with their patent-rights run out and great competition the same product now sells at about 6d., and this firm is now loth to make it. This gives one an idea of where these concerns obtain their profit.

The evils of trusts have of late years been exposed, and although we expect those evils to arise as a matter of course on the other side of the Atlantic yet it has been shown that we may be threatened by a country nearer home. In Germany there is a tendency for businesses to come to a common agreement. A kind of executive government of the heads of the various businesses is formed and they agree upon a joint government ruling output and sales. They also fix the home price and sometimes the "Kartell," for such is the arrangement termed, pays a bounty on exports if there is any loss occasioned by being compelled to sell at a low price abroad. The loss

is thus distributed among the various businesses and does not cripple one. The kartells differ from the present form of most of the American trusts in that they have not advanced to a unified management of production; they are combinations for maintaining prices, and, more or less, for the joint marketing of the produce by a number of concerns which retain their own independence as producers. It must be said that combination often checks unhealthy competition and provides up-to-date conditions and machinery. If well worked and organised a trust may be the very best of economic factors. Large scale operations are, within limits, the most profitable, and further, the workmen may be placed under better conditions than with the small individual manufacturers. In the United States the tendency is rather for the combination to become an individual business and a trust is formed by a sale of businesses to a company; you get one huge combination swallowing up the rest. In Germany and in England businesses show an inclination to get larger, but not to the same extent as in the United States. Moreover, in England the degree of trade combination is considerably less than in Germany and America where this artificial state is aided by another artificial restriction, viz., the high tariff. The German kartells have notoriously sought to relieve the home market in time of depression by selling abroad below the domestic price.

Reviewing these facts we come to understand our position. The dye-works of this country are so dependent on dye-stuffs imported from Germany that it is not pleasant to conceive what would happen if supplies were stopped or tampered with. Any rupture in the trade between the two countries would lead to most serious difficulties, and our trade in other markets might be permanently and irretrievably hindered. Prices are becoming so much cut in the East that increases in the cost of production, however slight, must be felt.

Turning again to the particular German kartells under discussion we find the combine between the Bayer, Berlin and Badische concerns has not been working long enough to tell whether it will be a success. One firm does not compete against another in the union on certain specialities, but this sometimes allows a firm out of the union to show itself. Thus one firm had a contract for years, and quoted for a renewal, having some idea of the price which the firms in the rival combination could supply at and knowing that the firms in its own kartell would not compete against it. The small outside producers had not been considered, however, with the result that the firm lost a huge contract which went to one of the smaller firms. Competition is very keen, and some of the smaller firms are making a big fight, employing the best talent they can entice from the big concerns. The large organisations have technical men all over the world, and these men meet from time to time at the German headquarters to discuss its vital matters of business. On one occasion one of the smaller colour firms sent men to stay at the same hotel as the other technical men mentioned, with the result that they heard all the doings of the conference discussed at the table. This they made use of with the result that all the firms have now given their staffs strict injunctions not to discuss business matters outside. Thus it is seen that the small firms are by no means dead yet, but, as said before, such a short period of warfare cannot effect much in such a campaign.

Combination will cause many colours to fall from the market. The separate firms produce many of the same things under different names and a series of the best colours will perhaps be arranged. This will lead to more specialised production, the separate concerns specialising in certain classes, and will also facilitate the dyer in his selection.

Our position in the colour industry has often been

pointed out and remedies suggested. Although large scale production has many advantages yet there is still room for the smaller firms to exist. As just pointed out, they do so in Germany, and there is no reason why it should not be the same in England. Germany is a long way behind us in the cotton and woollen industries, but yet she is gradually decreasing the gap. Although the larger the scale of production the more profitable production usually is, yet countries cannot be conceived as having large and unconquerable starts over other countries. One English firm is at present making itself known to the continent, and by the excellence of its products is receiving respect from German chemists. Their dyes receive very favourable reports, while recent literary issues from the works in question show no lack of enterprise. The Germans recognise their position and are leaving no stone unturned. They perceive that the subsidiary colour industry must grow with the cotton and woollen industries, as pointed out in Die Teerfarben Chemie in den Jahren, 1904 and 1905, in Zeitschrift für angewandte Chemie, June 29th, 1906. It must always be remembered that the German industry flourishes to-day for the same reason as our industries flourish—because of the application of keen business ability in the management. Yet many people in this country have sought other means of bringing about the revival which they desire, and protection has been suggested.

We, in England, are sending dye-stuffs to compete (and successfully too) in foreign markets, but we are importing far more than we export. Protection would have little effect in keeping out the German dye-stuffs and the price of our dyed goods would only be raised. Then on getting to a certain point establishments would be erected here by the German firms in order to escape the tariff as has been done in France, Russia, and other countries. This artificial situation would apparently better employment

but the national benefit would only be a small one as we have seen from American capital sunk in engineering enterprise in this country. Our present producers of coal tar colours would not benefit because they would not be allowed to work the patents of the German concerns, so our manufacturers and dyers would still have to buy from abroad or fall behind in the producing of up-to-date shades of colour. To get these novelties which are so often appearing on the markets we would have to pay the ordinary price together with the tariff, so the community in general would be placed at a disadvantage. Manufacturers who wish to benefit their industries should look out for some reasonable and practical method and not sue Parliament for a bounty from the community in general. In Germany, many raw materials for use in industry are admitted duty free as coal, lime, tar, pitch, turpentine, wool and hair, raw copper, lead, tin, zinc, hides and skins, and some chemicals, but not alkali, alum, bleaching powder, or salt; so, taking our case, are not aniline colours raw materials to our cotton, woollen and other industries? America taxes salts and most chemicals, but white arsenic, sulphur, and crude nitrates are free, besides petroleum, tar, turpentine, and wax. She, like Germany, recognises that raw material for her industry should, if possible, be untaxed. Whatever foreign tariffs and bounties may be, the community has prosperity substantially in its own hands since the bulk of exchanges are done in the country itself, this prosperity depending on the mutual industry of the members of the community, provided that the supply of raw material is not tampered with.*

Another solution of the question of aiding our decaying industry and one which deserves more attention, is that relating to our patent laws. These laws were intended to introduce new industries into the country, but by granting

* Sir R. Giffen, "Economic Studies and Enquiries."

patents to foreigners we have prevented the development of many processes at home and foreigners coming to this ountry have been granted monopolies which their own country refused them. It is generally conceded that making the inventor work his patent in the country where it is taken out—a method adopted by all European countries except our own—is the best direction for reform, and the Society of Chemical Industry is working to that end. The Germans worked our patents in their own country at the beginning of the coal tar industry and were so successful as to firmly establish themselves financially. Their progression after this impetus has been mentioned above. "English brains created the colour industry, English enterprise developed it, and English legislative folly has been the principal cause of its decline." * The reform of the patent laws will create free trade in ideas—what England has most need of. America does not force foreign inventors to work their patents there, but the high tariff has practically the same effect. The question of patents must be studied very carefully to ensure against possible evasion. The case suggests itself of an inventor working his patent here on a very small scale in order to come within the proposed law and thus preserve his monopoly, although at the same time his greatest establishment is in Germany. Legislation regarding patents is of great importance and the German technical schools have lecture courses in the subject.

Turning to the particular examples of patenting we find the German firms, immediately they discover a new colour, patenting it all over the world. Of course the chemists turn out many colours which, after consideration, are not put on the market, but those which are considered worthy are well guarded and patented. One German firm employs for this purpose a man who holds a doctor's

* Ivan Levinstein, "Nature," 1903.

degree both in chemistry and in law. Looking down the lists of patents one can always see examples of patents taken out in this country by the German firms. This is going on week after week and we might conceive of a time when the chemical part of the colour industry will be so far developed that little further can be done. After a term of years all patents will have run out and manufacturers will have equal rights. This would give our manufacturers an equal chance, but how far distant is this ideal position? The Germans, recognising the position, are continually bringing out new things and making their profits out of them while they are *new;* the price continually sinking. They are spending largely on research and recognise this as their only means of existence.

Above are a few facts relating to the German colour industry and what can be learnt from it. England has set examples to the world and has been copied on all hands in many business matters and so has created many competitors. Let us now change positions and, in observing the ways of the German concerns, recognise that imitation of those methods is the best road to success.

As to the separate colour works, it would fulfil no purpose to give full details of all these concerns, as other sources can be consulted. Yet a little general information concerning these epoch making organisations may be welcome.

The five largest works are the Badische, Bayer, Höchst, Cassella and Berlin, before mentioned.

The Badische was founded in 1865, providing work for thirty people. In 1900 they employed 6,200, and had a capital of 21 million marks. They have works in Germany, France and Russia, and in 1900 employed 148 scientific chemists, 75 engineers and 305 clerks at the German establishment.

The development of the Bayer firm is interesting, as

showing the change from the sale of the natural colours as indigo, safflower, etc., to the manufacture of magenta and its cogeners in 1860, and in 1870 to the production of alizarin and its derivatives. Later they produced their benzo-purpurines and delta-purpurines (their important groups of substantive cotton colours) and then with the yellows, blues, etc., brought out a whole series of direct dyeing cotton colours. Next came diazotising colours, diazo blacks, and para red, followed by the copper sulphate treatment of dyed pieces. Diamond blacks followed, then alizarin cyanine brands and brilliant alizarin blue. They were not behind when sulphur colours came and produced the first green. This firm has advanced more quickly than the other firms, until now it is one of the most important. It is significant in this connection to note that they have the most patents and employ a greater proportion of trained chemists. They have 1,000 German and 1,200 foreign patents.

I found in these works that the business side was highly developed, and in many cases they were almost self-sufficing. They make all they possibly can for themselves. It struck me that perhaps much of their success was due to strict attention to minor details, and certainly nothing is left undone in the commercial and despatching departments. Passing through the departments in which the different handbooks are made, one is struck with the enormous trouble and expense of such productions. Many of these are quite artistic, containing scores of patterns, all of which have to be fixed in by hand. These patterns are issued for cotton, wool, half-wool, silk, half-silk, leather, soap tints, straw, buttons, wood plaits for hats, wood stains for picture frames, etc., and the intending customer is thus presented with reliable and trustworthy samples of the dyed article, besides elaborate instructions

how to perform the dyeing. Also some of the handbooks give the latest machinery in use, and although this is of German manufacture, yet we get an idea of what is being done in Germany. The books are issued in about a dozen languages, including Japanese. The importance of good pattern books exists in all trades, and perhaps the Germans have developed this branch of business to its highest existing stage. Hundreds of clerks are engaged, and from the scores in the English departments, occupied solely in the trade with England, one gets some idea of the magnitude of that trade.

In all cases we find the works built so as to facilitate transport. Most of them are situated on or near the Rhine, while the Berlin company have their works on the Spree, and are thus in connection with Hamburg. All have the very best of railway communication and in some cases private lines.

As one stands on the banks of the Rhine and sees the many barges floating down stream, one is reminded what a mighty factor this stream is in German commerce. Here we have no large initial capital expenditure, as with our canals, but a natural means of the cheapest transport, taking the products of the Empire down to the sea, and with further cheap transportation, enabling them to compete where otherwise they would be hopeless. Consider a works at Mannheim and an English works in competition for supplying Liège with a heavy article as alkali. At Mannheim we float down the Rhine, connect by a canal with the Meuse, and arrive at Liège by water. Taking the English case, we can easily conceive of an enormous transportation bill driving our goods from the market. The importance of cheap transport is becoming greater and greater, and it may be said that England, both in internal and external communication, is the home of

transport anomaly. The way that some foreign goods are carried cheaper to parts of England than our own produce is, and that English ships take other people's goods a greater distance at a cheaper rate than ours and thus defeat us in some foreign markets, is deplorable. The enormous development of Rhineland as an industrial district has resulted largely from the industrial factor—the Rhine—and this should not be lost sight of when comparing the relative growth of England and Germany. It is said that the Thames has done more for England than all its canals and perhaps even its railroads.

Another interesting part of the colour works is the part where the dyestuffs are actually produced. For different dyestuffs the methods of production are different, but I saw rooms of about 70 feet high, with three and four storeys at the side, from which heights different mixtures were run into one vat to produce the dyestuffs by interaction. The dyestuff settles out, and by filtering through presses it is obtained like clay. The liquid filtered off is further utilised, and the clay-like mass is put into barrels and taken to the drying ovens. These ovens are heated from below by fires in the ground, the dyestuff being wheeled into the ovens on the level. Different temperatures are used for drying according to the nature of the dyestuff to be dried, and the ovens are specially constructed to admit of regulation. The dyestuff is dug out of the barrels by means of spades on to trays for placing in the oven, and in this transference the workmen seem little to consider the value of the stuff they are handling. Dyestuffs of all kinds are scattered about, giving the ground a peculiar colour on a wet day.

The above is only an example of one class of colour making, but all kinds were witnessed. Alizarin was seen in progress of production; mills were seen making paste

from it. Walking through these departments, past engines, filter presses and stinking waggons, one comes across workmen of all colours emerging from their working quarters and making for the baths. In all the works the baths are well conducted. Each labourer who is engaged in dirty work has to have a bath before leaving the works, and from what I saw he needed it.

The making of ice is also an important item in colour manufacture, because many tons are used daily for cooling purposes. At one works, iron boxes, standing vertically in brine cooled by an engine, were filled with water, and agitated by a lever arrangement. When frozen the pieces of ice were tilted into a waggon and the box again filled with water, and lowered into the circulating cold brine. The ice-making machinery is usually very large, and some works use as much as 200 tons of ice daily.

As previously mentioned in connection with dyeing in Germany, water supply is a big item. Bayer's Leverkusen works is on the Rhine, near Cologne, but they do not get their water from that river. It is pumped out of the ground, and I was told it came from the mountains in the neighbourhood of Elberfeld. The pumping engines are very large, capable of raising 60,000 cubic metres of water per day, a volume 10,000 cubic metres in excess of the daily consumption of the whole city of Cologne. Of course so much is not at present used, but the whole of this new works is designed for future needs, and in the method of building plenty of room for expansion has been allowed.

I also saw at Nürnburg a works where colours of a different class are made. Nürnburg contains many industries, and among these, mirror making and lithographic supplies are prominent. At the works mentioned fine metallic colours were being produced by heating powdered metal with aniline colours. Different alloys of

zinc and copper are used. Aluminium cannot be added, as the slightest amount produces brittleness and spoils the whole melt. Aluminium is, however, used alone. The price of this metal has increased 50 per cent. during the past year because of an understanding between the owners of the factories at Neuhausen and those in America. A monopoly has been created by the concerns determining that the European firm should supply Europe and the American its home market, and thus save competition. In the case of copper, only the purest metal, usually electrolytic, is used, and is beaten out by hammers and washed with sulphuric and tartaric acids. The colours are used for wallpapers, print cloth, lithography, etc., and the trade with Great Britain is large.

In recnt years marked strides have been made by many English employers towards the housing of their servants. The well-known English model villages cannot be surpassed anywhere, but the same conditions have arisen almost simultaneously in Germany, and business men in both countries have found out almost simultaneously that it more than pays them to look after the health of their employées.

In Germany, the large colour works are prominent in this matter, and Ludwigshafen, Höchst and Leverkusen provide good examples. At Höchst there is quite a town of artisan dwellings, each of which has a garden. Also there is a store, where provisions are procurable at almost cost price, a school for children, a continuation school for workmen, a library, an assembly hall, a huge dining hall, and many other conveniences. Höchst itself is a very dirty place, but by means of a policeman and the increasing intensity of the odours proceeding from one of the works' chimneys, I found my way through the unpleasant quarters to the much better locality, where the colour firm's work-

people live. The neat dwellings are in big contrast with the squalid shanties in the adjacent town. It must be mentioned that it is only the more respectable part of the workpeople who avail themselves of these conditions. The lowest classes find other places of abode. At all the works I found good kitchens providing excellent cheap dinners. Besides the above convenience, one finds at some of the works savings-banks, hospitals of all kinds, long service premiums, workmen's relief funds, musical societies, clubs, etc. A director of one concern sends workmen's wives and children to summer resorts, and pays for milk for the little ones at certain times of the year. A pension fund has reached such enormous dimensions at one works that one wonders if all the hands are about to avail themselves of it and retire on their means. The German firms are making huge profits, and some of these returns they are investing in the best possible and most productive way—that is, of caring for those who labour to make the profits.

At Mülhausen there exists a colony of a different kind. This was founded in 1850 to improve the conditions of the people of the town. It consists of about 1,000 houses with small gardens, which are sold to artisans at almost cost price. The district, at the present time, is hardly in the best of condition, and the workmen are tending to live further out, coming into town by train. There are baths, washhouses and schools in the colony, but it appeared to me a mixture of disorder and small businesses, only a part of the houses being used after their original intention.

Returning to the German Colour Works, we find in the *technical departments* chemists engaged as analysts, as research chemists and as technical men.

The first class treat the works materials and products, analyse the products of other firms, attempt to detect infringement of patents, etc. The research chemists are

under the direction of the finest chemists in Germany, for example, Duisburg and Bernthsen. A list of the chemists who have been employed from time to time by these firms shows that the best brains have been attracted, and the same conclusion is formed as to the present state of affairs, when one surveys the list of the distinguished chemists who came from Germany to England for Sir W. H. Perkin's coal tar colour jubilee.

The technical men are concerned with the dyeing properties of the products. In this department, all the dyestuffs of their own and of their rivals are used under all conditions, and thus the properties determined. As soon as a dyestuff is issued by a rival firm it is first analysed and then investigated by one of the technical men. A conference is called, at which this particular chemist reports on what he has found, and suggests what can be put against it from among their colours. Thus their travellers are provided with information to defeat the new product. If one of their customers mentions the advantages of the new stuff they are soon ready with the information to convince him that there is no need for such a thing on the market, and that by mixing their own —— BX with a little —— 3R they can get the same result better and cheaper.

The men who do the dye-testing last mentioned are generally university graduates, who come there to be trained as travellers or as technical men. Some go out as representatives all over the world, while others stay at home as superintendents of the different departments. Nearly all the heads of departments and those occupying high positions in the actual manufacture of the colours have gone direct from the university into the works, and the efficacy of employing university men is well shown. No industry employs more graduates and no industry is

more prosperous. The men gradually rise and occupy the highest of positions, whereas a man without a High School or University training finds a difficulty in advancing. A "good practical man," as the saying goes in England, might discharge the duties all right, but as a rule he cannot suggest improvements, keep in touch with progress through the journals, etc.

University graduates and others are received for training to be technical men at a salary of about £100 a year, and contract for one year. If during that year satisfaction is given their salary is gradually raised during a pericd of five years, for which a separate contract is made out. Most of their servants are under similar contracts. On any breach between employer and employed the latter for two years is not allowed to go to a rival organisation, but during that time he receives his salary. In this way a man who has gained secrets in any department cannot so well allow another firm to benefit from them because, after the two years agreed to, the industry might have so progressed in its present rapid development that his knowledge may be of little use. During the first year or more the men engaged as above-mentioned are merely learning and doing little for the firm. It is true that from time to time they have to report on various products, as before stated, but most of their time is taken up with picking up as much practical knowledge as they can, in order to fit them for subsequent positions. They are, most of the time, left to themselves, experimenting as they wish, using the splendid library and learning. The men meet periodically, and anything new in the technical world is reported and discussed. Also the technical papers are passed round and thoroughly perused. In this way all are kept thoroughly in touch with progress in the industry. Splendid libraries are often at their disposal as some of

these firms possess some of the best chemical libraries in the world.

The actual dyeing is done in a laboratory containing machines and different apparatus for dyeing, and labourers dye from directions given them by the gentlemen who are experimenting. Machines of modern kinds are kept, and the different dyestuffs are put to rigorous experimental tests.

After a certain time at this work, and when the directors think their new servants are sufficiently trained, a move is made. If the men have not previously worked in a dye-works they are sent into one for a short time. If a man is intended to travel in England later, then he is sent into an English works which is on good terms with the colour works, and in this way he learns in about six weeks a little about the organisation, equipment and occupation of the works which some day he will perhaps be called upon to visit. After this training the man returns to the experimental laboratory, and after a short time is ready to carry out the work for which he is intended. Some go abroad, and some travel in the district near the works, returning perhaps weekly. All the travellers return to the works from time to time, but with men, for instance, in America, the frequency of such visits is not as great as with the servants working in the vicinity. These men have also a use which must not be forgotten. At a certain printworks the chemist had died, and it was found that without him the works could not go on. During his lifetime he had kept secret all his recipes, having different signs for different materials, so that, when he died suddenly, there was no means of finding in what way and with what materials he had made the mixtures for the firm. The works was at a standstill. They applied to a colour works, who sent one of their men to do what he could. He

worked assiduously, and in three weeks had all in order again. This was a big change from the helpless state of less than a month ago. But there was also another difference. The chemist made up the recipes to contain only the colours of the firm from which he was sent, so in this way the firm using the new recipes were forced to buy the whole of their dyes from the works which sent the technical man.

A huge staff of research chemists is employed. Their remuneration is moderate, but successful patents lead to increased earnings. Many chemists are drawing large amounts in this way. The patents are taken out by the firm, and if successful, the inventor gets his share. This is a good system, and certainly incites the men to their best efforts. Pure chemical research has been found to pay; whereas empiricism has been found lacking. The preparation of a new dyestuff is usually brought about after its constitution or that of its cogeners has been found—for instance, the formula for indigo was given by Baeyer before he worked out its preparation, and the whole series of magenta colours were invented from studying the formulæ and introducing groups of different molecular weights to produce different shades—but with the sulphur colours we do not know the constitution, and if this information be found no doubt the present difficulties in inventing new colours of this range will be eliminated.

The different colour firms strive after a variety of products because business in any one may lead to trade in others. For this reason the travellers of some firms have been known to urge their employers either to make indigo or to sell the natural variety in order that they might satisfy all classes of customers.

In the works each man is confined to his own depart-

ment, and in no case allowed to wander. I spoke with men of high position who had not been out of their own small building in the works.

There is a case on record of a chemist engaged at a school, who used to speak against the colours of one firm. This firm gave him a good position to keep him quiet.

The experimental dyehouse at Höchst (Meister Lucius and Brüning) is about 30 yards square, and is fitted with small machinery, pots, and other requisites for dye trials. Round the sides of this laboratory there are smaller laboratories in which the chemists perform their work. Different rooms are set apart for different purposes, as cotton, wool, and silk dyeing experiments, paper dyeing, indigo dyeing, etc. A large number of chemists are employed, and here as at other German works, I found Englishmen. It is a peculiar thing to find our countrymen aiding production in foreign countries and fighting our own industry; they go where their services are most appreciated. In the indigo room the familiar spider web-like hexagonal frames were being lowered into vats, taken out and kept in the air for fifteen minutes. Volunteers (see page 103) also work in this department, and they have good opportunities for learning. Just previous to my visit to this works one of their men had invented a machine for dyeing cotton a series of colours which blend into one another. It consists of a pair of rollers between which the cloth is fed. The lower roller, instead of being all one piece, is made up of numerous sections, the sizes of which vary, and each section fits into a separate little trough. The machine is like the ordinary padding machine except that the trough and the lower roller are in sections. Different dye solutions are placed in the sections of the trough, and in this way the cloth is dyed differently in different parts. If different strengths

of dye liquor be suitably used, beautiful blendings are produced, and the variety and perfection of the effect depends on the number of sections in the trough. They had many varieties at work. There is another trough exactly corresponding to the former for the purpose of filling it with dye liquor. The operation is capable of minute regulation. The machine is made by Haubold's.

In Cassella's laboratory they have cop dyeing and other machines. Also a French modification of the Mather and Platt steamer for steaming at 140°. People on the Continent have great faith in the Mather and Platt, but it was urged that this French machine was better for their special purpose. Cassella's printing trade is rapidly growing, and consequently their experimental printing department shows the same change. Their experimental laboratories appeared well conducted, but were rather old. In the different machines some patterns are dyed, but most of them are obtained from manufacturers using their dyes. The people who labour for the technical chemists start very young, and finally attain to such skill that they can dye quite well without direction. Their wages are very small, the work being quite mechanical. The weighing out of the dyestuffs is done in a separate room, usually by girls. Some young men were engaged entirely in testing fastness to soap, reagents, temperature, etc. Manufacturers send a pattern with instructions that the dyestuff desired must be as fast as in the sample. This necessitates testing, and it is a good principle of Cassella's that they never rely upon previous trials. Everything is tested again, and although this means a good deal of trouble, yet, they say, it pays in the long run. In testing the strength of a dye, and comparing it with a pattern, all the dye is salted out on to the material, and afterwards another piece is put into the liquor to tell

whether the bath is exhausted. This is attached to the first dyeing, and the intensity of the second dyeing is taken into account when making a judgment. The eye alone is used in judging.

The Badische have a machine in which the cop dyeing is done by frothing, an Obermaier machine for loose material, and a Pornitz cop dyeing machine. Felting was done by working the stuff with soap between two slabs of wood. In the paper department a certain amount of semi-solid pulp from the paper-making machine is mixed with water and stirred with a certain amount of dye by means of a vertical stirrer. This is filtered at high pressure, and the paper thus formed is rolled, dried first between paper, then in the steam bath and compared with the pattern. In the leather dyeing department skins were shaken with solvents to extract the fatty matter, and then dyed back to back to prevent the flesh side of the skin from taking up the dye and wasting it. Sometimes the skins are dyed by merely painting them. Leather was being dyed direct in machines similar to those used for wool, and afterwards polished in a machine provided with a small smooth roller.

At Berlin they have a neat arrangement for milling, the material being moved backwards, forwards and sideways between rods driven by different eccentrics. In one room at this works I saw a large wall of boxes used to contain the products of competitors. In the very keen competition each firm finds it necessary to learn as much as possible of what the others are doing.

The large German concerns have departments in which men are trained to dye their products in all possible ways The facilities offered vary with the different firms, and whereas with some the volunteers are kept apart, in others they move freely in the technical laboratories.

This scheme is advantageous to both sides. The firm profits because the volunteer learns to dye their colours thoroughly, and, since he is under contract not to volunteer with another works for one year, he afterwards uses in the practice the colours he has learned so much about. The student gains in general knowledge, for he dyes things which he has perhaps not even seen before, the dyeing of which is nevertheless of importance. He is left to his own choice, and may dye wool, cotton, half wool, wool and mercerised cotton, silk, half silk, jute, linen, ramie, artificial silk, etc.—one or all. He is placed under a competent chemist, and with a fine library at his disposal it is his own fault if he does not acquire some knowledge. He also has an opportunity of getting in touch with the scientific journals, for, in spite of what we hear every day against book and newspaper knowledge, it must be admitted that the scientific press is one of the largest factors towards progress, and those who wish to keep in the front rank must keep well in touch with the matter in the journals. Experiments and trials on all the latest things in the dyeing world may be made in the laboratory. Men come periodically to these laboratories, afterwards returning to the works, and thus keeping in touch with progress in the art.

The volunteer laboratories are only for dyeing small samples, sets of dye baths with steam and calcium chloride solution heating, and good drying arrangements being supplied, but, as before stated, the volunteers are admitted to the large technical laboratories where experiments on a larger scale are performed, cops dyed and jiggers used. Volunteers assist in the experiments, and are further admitted into the printing, paper dyeing, leather dyeing and other departments. Pattern books are supplied in which a record of all things dyed is kept, and these books

are of practical use, since the particulars can be relied upon, having been performed by oneself.

One also mixes among dyers of all nationalities, and thus learns what they dye at home, how the industry is dispersed throughout the world. A Hungarian is seen specialising in shoddy dyeing, a Belgian busy with wool, a Frenchman with cotton and silk, an Austrian from Reichenberg studying the sulphur colours, and so on.

The advantages to be gained are many. After studying at an English University or Technical School, by spending a few months in one of these German laboratories, learning what there is to be learned there, and at the same time picking up some German by intercourse and reading the journals, a student has a good preparation for entering the industry at home, and these laboratories form an intermediary which, some maintain, is needed. Two great trusts are arising in Germany, and a few months spent in the laboratory of either of them, together with visits where possible to German dyeworks, will be found of practical benefit. I have heard of cases of entry to these laboraties without any knowledge of dyeing, but a great mistake is made if these institutions are substituted for technical schools. Both have their place. It is a peculiar thing that Englishmen seldom patronise these departments.

As to which laboratory is the best to enter, opinions differ. The laboratories at the Badische and Höchst appeared the best, but the instruction at Bayer's is certainly good.

One firm formerly paid its volunteers, but found itself overwhelmed with offers. Remuneration has been discontinued, but, considering the expense the firms go to and the facilities offered, I must conclude that "volunteering" is worthy of the consideration of any ambitious young dyer.

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